



NASA FILE COPY

Budget Estimates

FISCAL YEAR **1984**

Volume I

Agency Summary

Research and Development



25th Anniversary
1958-1983

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

VOLUME 1

TABLE OF CONTENTS

AGENCY SUMMARY

	<u>Page No.</u>
General statem	AS 1
Budget sum ay.....	AS 4
Program highlights.....	AS 5
Summary reconciliation of appropriations to budget plan.....	AS 10
Distribution of budget plan by installation.....	AS 11
Summary of permanent positions by installation.....	AS 12
Organization dat	AS 13

RESEARCH AND DEVELOPMENT

General statement.....	SUM 1
FY-1983 Congressional budget crosswalk	SUM 11
Appropriation language (proposed).....	SUM 12
Program and financing schedule.....	SUM 13
Research and development budget plan by subfunction.....	SUM 16
Distribution of research and development budget plan by installation and fiscal year.....	SUM 17

LIBRARY
National Aeronautics and Space Administration
Washington, D.C. 20546

TL
521.2
728
458
1984
V.1

Justification by program:

SPACE TRANSPORTATION PROGRAMS

Budget plan	ST 1 thru ST-2
Capability development	RD 1-1 thru RD 1-37
Operations	RD 2-1 thru RD 2-13

SPACE SCIENCE AND APPLICATIONS PROGRAMS

Budget plan	SSA 1 thru SSA 4
Physics and astronomy	RD 3-1 thru RD 3-24
Life sciences	RD 4-1 thru RD 4-10
Planetary exploration	RD 5-1 thru RD 5-15
Solid earth observations	RD 6-1 thru RD 6-14
Environmental observations	RD 7-1 thru RD 7-24
Materials processing in space	RD 8-1 thru RD 8-5
Communications	RD 9-1 thru RD 9-11
Information systems	RD 10-1 thru RD 10-2

<u>TECHNOLOGY UTILIZATION PROGRAM</u>	RD 11-1 Thru RD 11-5
---	----------------------

AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Budget Plan	AST-1
Aeronautical research and technology	RD 12-1 thru RD 12-42
Space research and technology	RD 13-1 thru RD 13-32

<u>TRACKING AND DATA ACQUISITION PROGRAM</u>	RD 14-1 thru RD 14-31
--	-----------------------

AGENCY
SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautics activities for peaceful purposes for the benefit of all. NASA's activities are designed to maintain United States leadership in aeronautical and space research and technology and its utilization. More specifically, the objectives of NASA activities are to:

- Extend our knowledge of the Earth, its environment, the solar system, and the universe;
- Expand the practical applications of space technology;
- Develop, operate, and improve manned and unmanned space vehicles;
- Improve the civil and military usefulness of aeronautical vehicles;
- Disseminate pertinent findings to potential users; and
- Promote international cooperation in peaceful activities in space.

The NASA FY 1984 budget recommendation of \$7,106.5 million provides for continued progress toward achievement of these objectives.

space program elements in the budget provide for progress in development of the operational capability and use of the Space Shuttle and related systems; in technology development for application of space capabilities to remote sensing of the surface and atmospheric conditions of the Earth and other planets, to materials processing, and to communications; in exploration of the solar system and expansion of our knowledge of the universe; and in advancing the technology necessary for United States leadership in space. Major areas of emphasis include:

- o The operational phase of the Space Shuttle system, which was initiated with the first operational flight in November 1982. In addition to the conduct of operational missions, this phase includes the

continued development of the operational capabilities and effectiveness of the Shuttle, the Spacelab, upper stages, and payload-related activities. The FY 1984 program will provide for the procurement of the hardware, mission integration and training, ground processing and flight operations of the Space Shuttle in support of the NASA, Department of Defense, domestic commercial, and international users of the Space Transportation System. The present fleet of two orbiters will be expanded by the addition of a third in 1983, and production activities will continue on the fourth orbiter, to be delivered in late 1984. The initial flight of the Spacelab will occur in 1983, and additional elements of the Spacelab hardware will be delivered. Development of versions of the Centaur upper stage for use by the Department of Defense and NASA will continue toward the initial flights in 1986 of two NASA planetary missions--Galileo and the International Solar Polar Mission and in 1988 of the Venus Radar Mapper. The FY 1984 program will also feature preparations for the introduction of improved Shuttle performance capabilities for high performance launch requirements using the lighter-weight filament wound case solid rocket boosters. In 1984, the Space Shuttle's capability to rendezvous with and repair spacecraft in orbit will be demonstrated with the Solar Maximum Mission spacecraft.

- o Space science and applications flight missions, research and analysis and ground-based activities are conducted to expand human knowledge of the Earth's environment, the solar system and the universe; and to develop the technology to use space capabilities to meet needs on Earth. Specifically, work will continue on the Galileo orbiter and probe mission to Jupiter as the next step after Voyager in exploration of the outer planets; on the Space Telescope to provide a quantum jump in our ability to observe the universe; on the Gamma Ray Observatory to study extremely high energy phenomena; and on the refurbishment of the Solar Maximum Mission spacecraft and instruments to return this system to full operational status with the aid of the Shuttle. Design and development activities will be initiated on the Venus Radar Mapper mission which will obtain global imagery of Venus. Landsat-4 was successfully launched in 1982 and work is continuing on the data processing ground system and on the engineering analysis of Thematic Mapper data which will improve the usefulness of solid Earth observations from space. In addition, effort will be continued on the Earth Radiation Budget Satellite to measure the exchange of energy between the Earth and space; on the search and rescue locator system to be flown on weather satellites, and on the Upper Atmospheric Research Satellite Experiments to monitor the upper atmosphere. Preparation for materials processing experiments to take advantage of the space environment, and initiation of design and development activities on the Advanced Communications Technology Satellite (ACTS), a joint effort with industry wherein industry would contribute toward the cost of developing ACTS, are also part of the space science and applications program.

- o Space research and technology activities emphasize the longer range aspects of generic research and technology development in transportation, spacecraft and space station systems which are crucial to future United States leadership in space.

Aeronautical research and technology activities in the budget are necessary to advance the aeronautical technology base for safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the long-term competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft. The FY 1984 program continues emphasis on the fundamental research and technology base in all disciplines and speed regimes vital to aeronautics. Specific technology efforts will continue to be directed toward major improvements in high-performance aircraft and rotorcraft. New initiatives will be undertaken in developing a preeminent numerical aerodynamic simulation capability, an advanced composite structures technology, and technology for the next generation of rotorcraft.

Resources Summary

The budget authority recommended for FY 1984 totals \$7,106.5 million with estimated outlays of \$6981.1 million and a civil service staffing level of 21,219.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

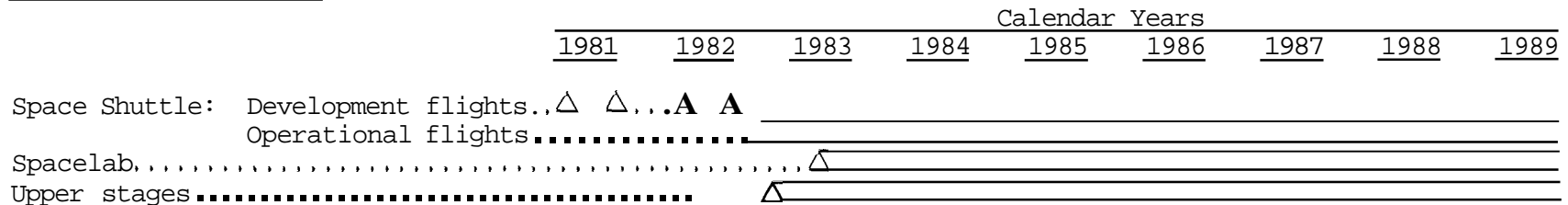
	Budget Plan		
	<u>1982</u>	<u>1983</u>	<u>1984</u>
<u>RESEARCH AND DEVELOPMENT</u>			
Space Transportation Systems	3,089,850	3,597,800	3,498,000
Space Science and Applications	896,200	1,034,100	1,068,000
Technology Utilization	8,000	9,000	4,000
Aeronautical Research and Technology	264,800	280,000	300,300
Space Research and Technology	111,000	123,000	138,000
Tracking and Data Acquisition	<u>402,100</u>	<u>498,900</u>	<u>700,200</u>
Total Research and Development	4,771,950	5,542,800	5,708,500
<u>CONSTRUCTION OF FACILITIES</u>	113,700	97,500	150,500
<u>RESEARCH AND PERSONNEL MANAGEMENT</u>	<u>1,134,350</u>	<u>1,199,050</u>	<u>1,247,500</u>
TOTAL	<u>6,020,000</u>	<u>6,839,350</u>	<u>7,106,500</u>
OUTLAYS	6,035,401	6,721,500	6,981,100

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Proceed with operations and development of the capabilities of a versatile and cost-effective space transportation system to provide for:
 - Expanded capabilities employing the reusable Space Shuttle system
 - Manned orbital experiments using Shuttle and Spacelab
 - Deep space and geosynchronous mission capability with upper stages
 - Orbital placement, servicing, and retrieval of automated satellites
 - Economy in transportation, space operations, and payload costs
- First operational flight mission accomplished in November 1982
- Provide support to increased Shuttle operational flight rate
- Continue production to provide a national fleet of Space Shuttle orbiters
- Proceed with development of additional Shuttle performance capability
- Proceed with activities supporting early demonstration of Shuttle on-orbit retrieval and repair capability
- Initiate development of United States-Italian Tethered Satellite System
- Provide expendable launch vehicle services as required by NASA and other users during transition to the Space Transportation System

MAJOR FLIGHT ACTIVITY



BUDGET PLAN

(millions of dollars)	<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
Space Transportation Capability Development	2623.4	2144.1	1927.4
Space Transportation Operations	<u>466.5</u>	<u>1453.7</u>	<u>1570.6</u>
Total Space Transportation Systems	<u>3089.9</u>	<u>3597.8</u>	<u>3498.0</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE AND APPLICATIONS

- o Increase our understanding of the evolution and nature of the Earth and its environment, the solar system, and the universe through a balanced program of space explorations missions and ground-based investigations
- o Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained
- o Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields
- o Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY

	Calendar Years							
	1982	1983	1984	1985	1986	1987	1988	1989
Space telescope.. ..				A				
Gamma ray observatory							Δ	
Explorer launches.. ..	Δ	...A Δ	...A			A	...A	...A
Shuttle/Spacelab payloads.. ..	A	OFT Δ						
Dedicated life sciences Spacelabs								
Voyager-Uranus encounter.....					U		J	
Galileo.....								
International solar polar mission (ESA space).....					Δ			
Venus radar mapper mission.. ..							Δ	
Landsat-4.....	Δ							
Search and rescue locator system								
on weather satellites.....	Δ							
Earth radiation budget experiment				Δ				
Advanced communications technology satellite.....							Δ	

BUDGET PLAN

(millions of dollars)	FY 1982	FY 1983	FY 1984
Physics and Astronomy	322.4	441.0	514.6
Life Sciences	39.5	55.7	59.0
Planetary Exploration	210.0	186.4	205.4
Solid Earth Observations	149.4	132.2	74.4
Environmental Observations	133.0	156.9	163.0
Materials Processing in Space	16.2	22.0	21.6
Communications	21.3	32.4	21.1
Information System	4.3	7.5	8.9
Total Space Science and Applications	896.2	1034.1	1068.0
Technology Utilization	8.0	9.0	4.0

National Aeronautics and Space Administration

AERONAUTICAL RESEARCH AND TECHNOLOGY

- o Provide the Nation with the fundamental research and technology in the aeronautical disciplines and vehicle classes to:
 - Improve performance
 - Reduce costs
 - Increase safety
 - Reduce energy requirements
 - Decrease environmental effects
- o Develop and sustain a strong Research and Technology Base in:
 - Fluid and thermal physics
 - Materials and structures
 - Controls and guidance
 - Human factors
 - Computer science and applications
 - Propulsion systems
 - Rotorcraft technology
 - General aviation/commuter technology
 - Subsonic aircraft technology
 - High-performance aircraft technology
- o Conduct focused systems technology to demonstrate the technical feasibility of technology advances or concepts:
 - Numerical aerodynamic simulation for complex aerospace computational problems
 - Advanced composite structures technology for transport aircraft design
 - Technology for next generation rotorcraft for X-Wing and advanced tilt rotor technology
 - Turbine engine hot section technology for higher performance and longer lasting engines
 - high-performance flight research
 - Advanced rotorcraft technology and flight research
- o Maintain expertise and operate significant national facilities to support research and technology:
 - Research and test facilities
 - Simulation facilities
 - Wind tunnels

<u>BUDGET PLAN</u>	<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
(millions of dollars)			
Aeronautical Research and Technology	264.8	280.0	300.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

o Provide a technology base essential to future United States leadership in space by:

- Improving performance and effectiveness
- Reducing cost and risk
- Increasing reliability
- Developing technological options

o Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:

- Fluid and thermal physics
- Materials and structures
- Computer science and electronics
- Chemical propulsion
- Space energy conversion
- Controls and human factors
- Space data and communications
- Multidisciplinary research
- Spacecraft, transportation, and platform systems
- Component standardization

MAJOR FLIGHT ACTIVITY

	<u>Calendar Years</u>							
	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>
Space technology Shuttle/Spacelab payloads.. ...A OFT.. A								
Long duration exposure facility.....			A					
Ion auxiliary propulsion system.....			A					

BUDGET PLAN

(millions of dollars)	<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
Space Research and Technology	<u>111.0</u>	<u>123.0</u>	<u>138.0</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TRACKING AND DATA ACQUISITION

- o Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:
 - Shuttle operational flights
 - Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and Solar Mesosphere Explorer
 - Planetary missions - support will continue for Pioneers-10 and 11, Pioneer Venus, and Voyagers-1 and 2, as well as limited support for Helios and earlier Pioneer missions
 - Sounding rockets
 - Aeronautical flight research program
- o The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft will be launched in early 1983 and the second in mid-1983. The TDRSS contract has been restructured to provide for a dedicated government system.

MAJOR FLIGHT ACTIVITY

	<u>Calendar Years</u>							
	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>
Tracking and Data Relay Satellite		A	Δ	...	Δ			
(Backup satellites available)								

BUDGET PLAN

(millions of dollars)	<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
Tracking and Data Acquisition	402.1	498.9	700.2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

SUMMARY OF RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

<u>Fiscal Year 1982</u>	<u>Total</u>	<u>Research and Development</u>	<u>Construction of Facilities</u>	<u>Research and Program Management</u>
Appropriation, PL 97-101.. .. .	6,187,200	4,973,100	99,800	1,114,300
Reduction, General Provisions PL 97-101				
Sec. 501 (41).....	-247,200	-232,200	-4,000	-11,000
Transfer between accounts FY 1982.....	---	-2,900	+2,900	---
Supplemental Appropriation, PL 97-257.....	+80,000	---	---	+80,000
Subtotal.....	6,020,000	4,738,000	98,700	1,183,300
Transfer between accounts FY 1983.....	---	-15,000	+15,000	---
Funded in R&PM.....	---	+48,950	---	-48,950
Total Budget Plan.....	<u>6,020,000</u>	<u>4,771,950</u>	<u>113,700</u>	<u>1,134,350</u>
 <u>Fiscal Year 1983</u>				
Appropriation, PL 97-272.....	6,809,200	5,542,800	97,500	1,168,900
Proposed Supplemental Appropriation.....	+30,150	---	---	+30,150
Total Budget Plan.....	<u>6,839,350</u>	<u>5,542,800</u>	<u>97,500</u>	<u>1,199,050</u>
 <u>Fiscal Year 1984</u>				
Appropriation request/budget plan.....	<u>7,106,500</u>	<u>5,708,500</u>	<u>150,500</u>	<u>1,247,500</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Millions of Dollars)

	Total			Research and Development			Construction of Facilities			Research and Program Management		
	1982	1983	1984	1982	1983	1984	1982	1983	1984	1982	1983	1984
Johnson Space Center.....	1,789.2	1,723.3	1,596.2	1,598.5	1,524.9	1,385.5	4.2	3.2	6.1	186.5	195.2	204.6
Kennedy Space Center.....	591.4	664.7	739.6	415.5	496.0	524.5	19.9	5.4	41.6	156.0	163.3	173.5
Marshall Space Flight Center.	1,395.8	1,784.8	1,814.5	1,200.0	1,577.3	1,608.3	23.7	23.5	19.5	172.1	184.0	186.7
National Space Technology Laboratories.....	18.6	15.7	20.0	9.9	7.1	7.2	2.1	2.3	3.5	6.6	6.3	9.3
Goddard Space Flight Center..	788.8	933.1	964.8	614.6	740.4	774.7	5.1	11.8	6.4	169.1	180.9	183.7
Jet Propulsion Laboratory..	319.7	323.6	355.2	316.2	319.7	346.1	3.5	3.9	9.1	---	---	---
Ames Research Center.....	298.8	293.6	324.1	175.3	176.3	205.0	22.4	9.9	10.3	101.1	107.4	108.8
Langley Research Center..	262.7	286.7	289.9	129.6	132.9	134.7	6.5	19.6	16.1	126.6	134.2	139.1
Lewis Research Center.....	285.6	373.8	368.1	175.1	250.9	229.8	4.1	7.0	16.4	106.4	115.9	121.9
Headquarters	246.9	429.2	612.6	137.2	317.3	492.7	---	---	---	109.7	111.9	119.9
Undistributed Construction of Facilities:												
Various Locations.....	12.2	2.6	3.9	---	---	---	12.2	2.6	3.9	---	---	---
Facility Planning and Design.	10.0	8.3	9.2	---	---	---	10.0	8.3	9.2	---	---	---
Total Budget Plan.....	6,019.7	6,839.4	7,098.1	4,771.9	5,542.8	5,708.5	113.7	97.5	142.1	1,134.1**	1,199.1***	1,247.5
			8.4 ¹						8.4*			
			7,106.5						150.5			

* Reimbursement to GSA for NASA utilized property of Ellington, AFB, Texas as directed by OMB

** Excludes \$.3 million lapsing

*** Includes \$30,150,000 for increased pay cost

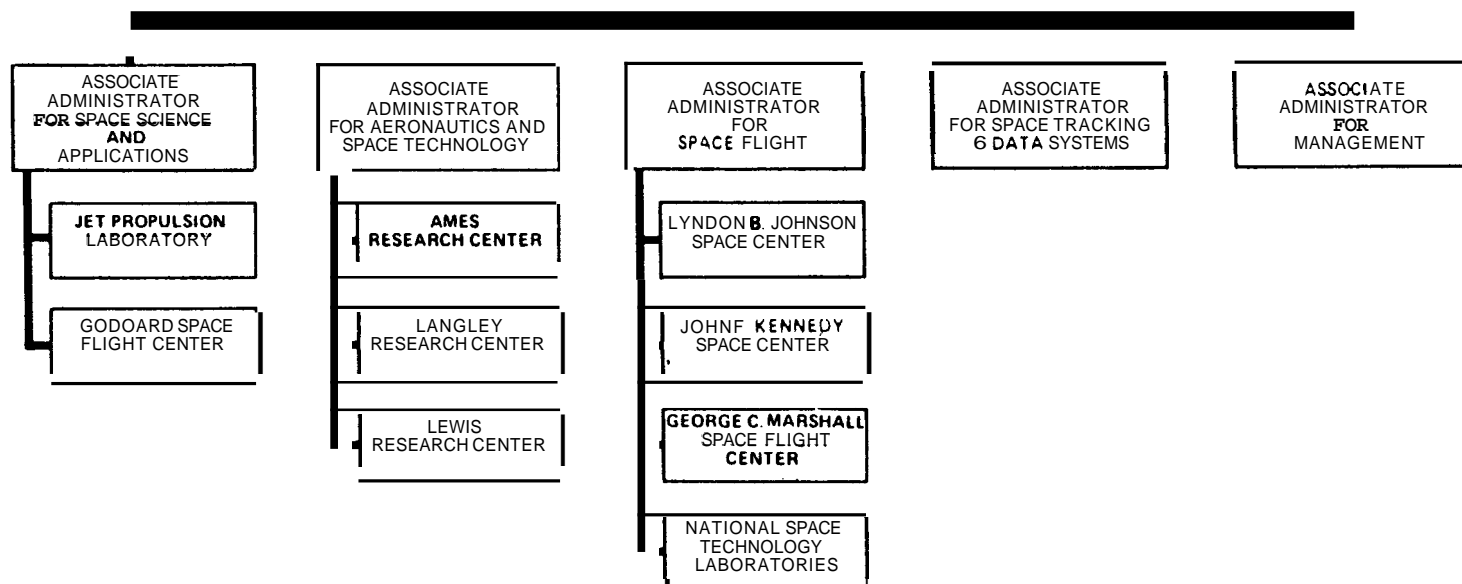
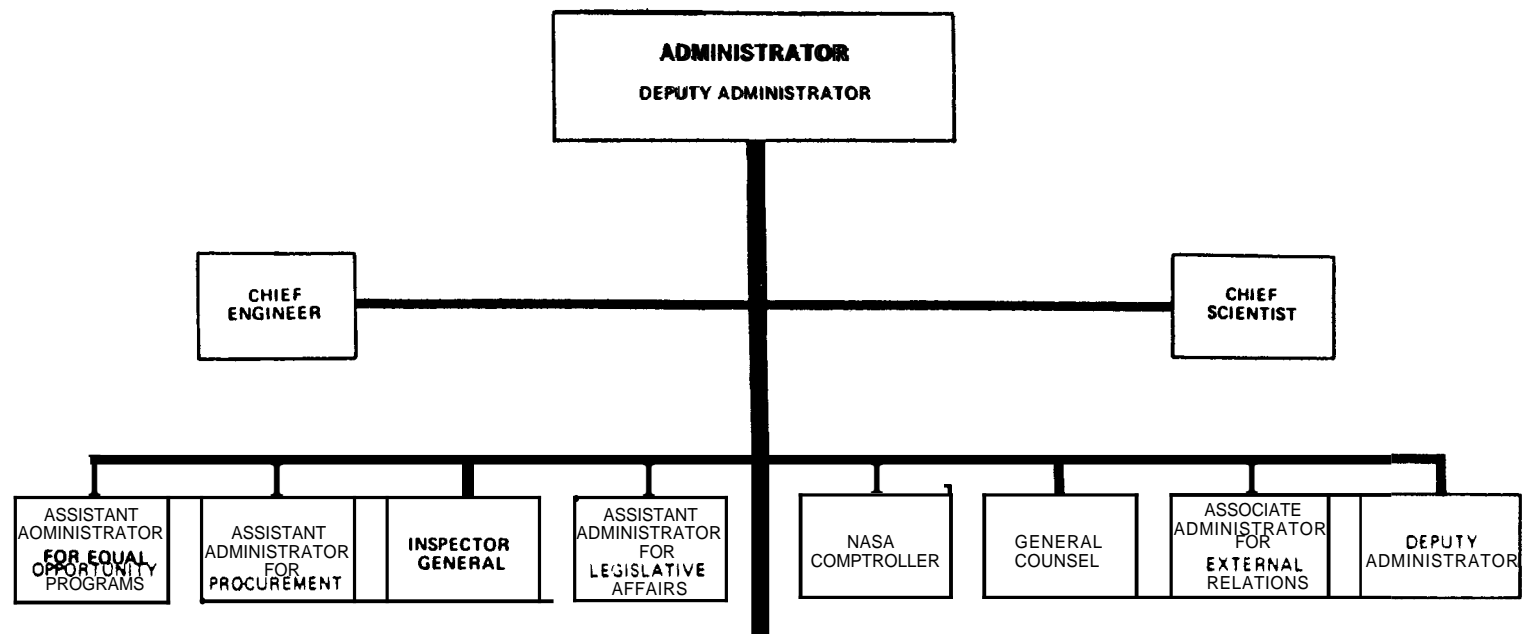
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1984 ESTIMATES

TOTAL NUMBER OF PERMANENT POSITIONSEND OF YEAR

<u>Installation</u>	<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
Johnson Space Center	3. 346	3. 293	3. 293
Kennedy Space Center	2. 133	2. 112	2. 112
Marshall Space Flight Center	3. 351	3. 285	3. 285
National Space Technology Laboratories	104	104	104
Goddard Space Flight Center	3. 661	3. 623	3. 623
Ames Research Center	2. 037	2. 021	2. 021
Langley Research Center	2. 866	2. 845	2. 845
Lewis Research Center	2. 663	2. 479	2. 479
Headquarters	<u>1. 491</u>	<u>1. 457</u>	<u>1. 457</u>
Total. Permanent Positions	<u>21,652</u>	<u>21. 219</u>	<u>21. 219</u>



RESEARCH
AND DEVELOPMENT

**SUMMARY
INFORMATION**

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology: to develop, operate, and improve manned and unmanned space vehicles: to provide technology for improving the performance of aeronautical vehicles; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE TRANSPORTATION SYSTEMS: A program to provide the transportation and related capabilities required to conduct space operations. The major objective is the production and operation of the reusable Space Shuttle and other elements of a versatile, economical space transportation system to provide round-trip access to space, and operational capabilities to meet civil and defense needs in the use of space.

SPACE SCIENCE AND APPLICATIONS: A program using space system, supported by ground-based and airborne observations, to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the other stars of our galaxy and the universe; and to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology: materials processing research and experimentation: and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

TECHNOLOGY UTILIZATION: The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology, and development programs.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental long-term research and to develop the generic and systems technology required to maintain the United States leadership in aeronautics and space.

TRACKING AND DATA ACQUISITION: A program utilizing a worldwide antenna network and a satellite system to support deep space, Earth orbital, suborbital and aeronautical activities.

SPACE TRANSPORTATION SYSTEMS

Space transportation system activities provide all of the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the operations, on-going production, and capability development of the Space Shuttle. The Space Shuttle, the first reusable Earth-to-orbit transport vehicle, is the key element in the Space Transportation System which also includes upper stages to provide high altitude orbit and planetary capabilities, and the Spacelab--principally developed by the European Space Agency--to provide a new capability for conducting experiments in space. The Space Transportation System provides the basic capability for a new era of operations in and utilization of space.

The Space Shuttle's versatility and reusability are key elements in opening a new era of expanded use of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle consists of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle provides unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to Earth orbit of payloads and propulsive stages for high altitude and planetary missions. The advent of readily available, economical transportation to and from low Earth orbit for automated payloads, as well as for scientists and other personnel, will revolutionize our concepts of using space and will expand the returns from space operations. The Shuttle's unique capabilities will not only lower the cost of space operations but will also lead to savings in the costs of payloads. These anticipated savings will result from repair and reuse of payloads and relaxation of weight and size constraints. The advantages offered by the Space Transportation System over existing expendable launch systems will enhance both the flexibility and the productivity of space missions.

Orbital flight testing and the delivery of the second orbiter were completed on schedule in FY 1982. The first operational flight (STS-5) occurred in November 1982, and marked the first use of the Space Shuttle to place commercial spacecraft into a transfer orbit. The system's capabilities will be further expanded in FY 1983 with the delivery of the third orbiter, the first use of the higher thrust level main engines, the initial flights of the lightweight external tanks and higher performance solid rocket boosters, the first dedicated Spacelab mission, the first use of the Inertial Upper Stage with the Space Shuttle, and the bringing into operational status of additional launch site capabilities.

In FY 1984, the flight rate will approximately double over FY 1983's five flights, with eight to nine flights planned. The first demonstration of the Space Shuttle's ability to rendezvous with, retrieve and repair a spacecraft in orbit is also scheduled for FY 1984. The production of solid rocket boosters and

external tanks for flights in 1984-1986 will continue, and the manufacturing tooling and equipment to achieve the higher flight rates will be put into place. New avionics software capabilities, the expansion of Mission Control Center operations, and additional Kennedy Space Center capabilities will be brought on-line during this period. NASA will also continue to support the Department of Defense's development of the west coast launch site for the Space Shuttle, leading to an initial operational capability in late 1985. The higher performance missions launched from Vandenberg Air Force Base will utilize the new filament wound case solid rocket booster on which development was initiated last year.

Start of development on a new capability for conducting space experiments is proposed for FY 1984. The Tethered Satellite System will be a cooperative program with the Italian government to enable experiments to be conducted at distances up to 100 kilometers from the Shuttle orbiter after the satellite is deployed on a tether and while it is held in a fixed position relative to the orbiter. This new capability will permit observations of important atmospheric processes occurring within the lower thermosphere, of crustal geomagnetic phenomena, of magnetospheric-ionospheric-atmospheric coupling processes in the 125-150 kilometer region in the lower troposphere as well as enabling entirely new electrodynamic experiments to be conducted. In addition to the Tethered Satellite System, a major area of advanced program activity will be the definition and advanced technology development for a possible future space station; studies and development tasks will be supported by other NASA programs, principally in Space Technology, Space Science, and Space Applications. Both contractor and civil service personnel from the NASA Headquarters and field centers are engaged in defining the mission requirements, technology drivers, and supporting capabilities (such as orbital transfer vehicles and teleoperator maneuvering systems) for a space station.

For FY 1983 and FY 1984, the budget plan for Space Shuttle Production and Capability Development provides for progress on the third and fourth orbiters for delivery in September 1983 and December 1984, respectively; for production and ground testing of the main engines; for orbiter spares provisioning, including the procurement of spare orbiter structures; for additional manufacturing tooling and equipment; for additional launch site and mission operations equipment as new and expanded capabilities are made operational; for the continued development of the Centaur as an upper stage; for additional Spacelab equipment and Spacelab mission operations; and for payload operations and support equipment, including the support of the Solar Maximum Mission spacecraft retrieval and repair.

In Space Transportation Operations, both the Space Shuttle operations and expendable launch vehicles provide for the support of a wide range of NASA, Department of Defense, other United States Government, domestic commercial and international payloads. The Space Shuttle is scheduled to fly from eight to nine missions in FY 1984, depending upon reflight requirements and identification of new mission requirements. These missions in FY 1984 and subsequent years require the continued procurement, assembly and checkout of the solid rocket booster, external tank, and replacement spares for the orbiter, crew equipment, and main

engine; the flight planning, avionics software verification, mission integration, flight control, crew procedures and training; and other mission oriented operations. In expendable launch vehicles, the Scout, Atlas-Centaur, and Atlas-F vehicles will support missions for which NASA is wholly reimbursed. The Delta will support both NASA and reimbursable missions through FY 1986.

SPACE SCIENCE AND APPLICATIONS

The Space Science and Application program supports systematic study of the Earth and its space environment, the solar system, the galaxy and the universe; and the research and selected technology developments to encourage the practical application of space technologies to needs on Earth. The space science and applications activities use space systems supported by airborne and ground-based observations to study the Earth and its atmosphere and space environment, the Sun, the planets, interplanetary and interstellar space, and the other stars of our galaxy and universe. Results from these investigations significantly contribute to our understanding of the universe, including the key questions of life, matter, energy, and the complex phenomena that have such a profound effect on life and the environment on Earth. In addition to remote sensing, space applications research and development covers the areas of materials processing, communications, and information systems.

Development of the Space Telescope will continue, leading to a launch in 1985. This multiple purpose telescope will be launched by the Space Shuttle, and will serve as a highly versatile astronomy observatory in space for over a decade. The Space Telescope will greatly expand the volume of space accessible for observation, contributing significantly to our understanding of the origin and evolution of the universe and its energy-generating mechanisms.

Work is underway on explorer spacecraft to study ultraviolet and infrared astronomy and the Sun-Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab. The Gamma Ray Observatory, initiated in 1981, will take a significant next step in high energy astrophysics. This mission will conduct a comprehensive whole-sky survey in the highest energy region of the electromagnetic spectrum, which will advance our knowledge of the nuclear processes occurring in the universe, and of the nature and dynamics of pulsars, galactic gamma ray processes, neutron stars, and black holes.

The Sun exerts a primary influence on the Earth and its immediate environment. The discoveries from the series of orbiting solar observatories, from the experiments flown during the Skylab program, and from the Solar Maximum Mission launched in 1980 to study the Sun during the period of peak solar flare activity, are revolutionizing our understanding of the Sun. The International Solar Polar Mission, a joint NASA and

European Space Agency mission, will provide information on the solar system from far above the plane in which the planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions as a function of solar latitude, and may allow us to gain insight into the possible effects of solar activity on weather and climate trends on Earth.

Orderly progress in the systematic exploration of the solar system is proceeding. The objectives of this effort are to understand the origin and evolution of the solar system and to better understand the Earth through comparative studies with other planets. Pioneer Venus provided basic information about the massive cloud-covered atmosphere of Venus. The Voyager I and II spacecraft, after providing a wealth of new information about Jupiter and its moons, made spectacular contributions to our knowledge of Saturn, its rings, and its satellites. Voyager II is now headed for an encounter with Uranus in 1986. The Voyager results have added to our confidence that the Galileo mission to Jupiter will also be a major milestone in planetary exploration. A major effort in FY 1984 will be continued development on the Galileo mission which will use a probe to make detailed measurements of the atmosphere of Jupiter and an orbiter to conduct extensive observations of the planet and its satellites. The Galileo launch is scheduled for 1986 on a Shuttle/Centaur upper stage combination. In addition, design and development activities will be initiated in FY 1984 on the Venus Radar Mapper (VRM) mission leading to a launch in 1988. The VRM will use synthetic aperture radar to map the surface of the planet Venus providing data that will enable us to trace its history exposing evidence of whether water ever existed on Venus. It will also enable observation of any volcanic activity there.

The solid Earth observations program's principal activities include the identification of user information needs, development of remote sensing and information extraction techniques, and provision for the acquisition of space data leading eventually to the establishment and routine use of global data collection systems. Currently, Landsat-3 and -4 are providing a wide variety of useful data. Landsat-4, with improved sensing capabilities, was successfully launched in July 1982, and both the flight and ground systems are performing well. The Thematic Mapper data received and processed to date are of excellent quality and holds promise for many new applications in civil remote sensing. NASA will support the National Oceanic and Atmospheric Administration (NOAA) in its new responsibility for managing the operation of the Landsat-4 system starting in 1983. Experiments designed to test the applicability of active microwave measurements were successfully conducted on the second Space Shuttle orbital flight test, and a large format camera to obtain high resolution imagery for mapping investigations is planned for flight on a Space Shuttle mission in 1984. Studies are also underway on advanced technology for improved remote sensors for multiple applications. Joint research activities are planned with other Federal agencies and coordinated with international organizations to advance the scientific knowledge of the solid Earth.

The environmental observations program objectives are to improve our understanding of the processes in the atmosphere and the oceans, and to extend the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional in extent, they can be most effectively, and sometimes solely, studied from space. Research on the dynamics and radiative properties of the atmosphere has shown that global observations available only from space may allow the extension of long range weather forecasts, from the current four to five days, to eight to ten days. New remote sensing capabilities, such as the Earth Radiation Budget Experiment, are being developed to provide the essential observations. Studies of the upper atmosphere are producing a better understanding of the distribution of ozone and other trace constituents.

Data from the instruments carried on the Nimbus, SAGE, and Seasat satellites are continuing to prove valuable in understanding many aspects of the environment. An effort is underway to determine how satellite altimeters can be used to measure the flow currents of the global ocean. Quantitative measurements of the chlorophyll concentration in the Ocean surface layer have been made: these data are being used to determine the productivity of the ocean.

The materials processing research activities have been designed to exploit the unique capabilities of spaceborne facilities for materials processing in the space environment, and to provide opportunities for independently-funded users to exploit space flight for processing activities related to their own needs. These activities are intended to encourage early transfer of space activity in materials science to private sponsorship. The fluid experiments system/vapor crystal growth apparatus will undergo ground tests in 1983, leading to flight in 1984.

The communications activities in FY 1983 and FY 1984 will focus on completion of generic proof-of-concept communications technology applicable to the Advanced Communications Technology Satellite (ACTS): the initiation of the design and development efforts on the ACTS as a joint effort between NASA and industry; the technical support to the United States Government for the World Administrative Radio Conference/Regional Administrative Radio Conference planning efforts: and continued experiment support to the Applications Technology Satellites 1-3-5.

The information systems activities will focus on support for space science and applications programs through the development of prototype data systems for standardization of space science and applications data requirements.

TECHNOLOGY UTILIZATION

Technology utilization activities are designed to accelerate the transfer of new knowledge and innovative technology generated by NASA and NASA contractors to the nonaerospace industry, as well as to State and local governments. During FY 1984, NASA will continue its efforts to assure effective and widespread dissemination of new technology.

AERONAUTICAL RESEARCH AND TECHNOLOGY

The objective of the aeronautics program is to provide the technology base essential for continued United States leadership in aeronautics. This technology base is needed for the development of future aircraft with improved performance, and underlies the strong competitive position of the United States in the world aviation marketplace and the continued superiority of the Nation's military aircraft. The requested program for FY 1984 includes a strong research and technology base effort, continuation of rotorcraft and high-performance aircraft systems technology activities, and new initiatives in numerical aerodynamic simulation, advanced composite structures technology, and technology for next generation rotorcraft.

The FY 1984 research and technology base activities maintain continuing emphasis on the disciplines of fluid and thermal physics, controls and guidance, human factors, computer science and applications, propulsion systems, and materials and structures. Focused systems research activities relevant to rotorcraft, high-performance aircraft and subsonic aircraft will also be conducted.

In systems technology, current efforts in rotorcraft guidance and navigation, Rotor Systems Research Aircraft (**RSRA**) flight research and advanced rotorcraft technology will be continued. A new initiative in technology for next generation rotorcraft will include efforts to flight test the X-Wing concept and pursue advanced tilt-rotor technology. In high-performance aircraft systems technology, research will continue in high performance flight and in turbine engine hot section technology. A new effort to develop composite technology for wing and fuselage structures and advanced composite materials will be initiated in subsonic aircraft systems technology. The initiation of a systems technology program in numerical aerodynamic simulation has the objective of significantly increasing the preeminent national capability in computational fluid dynamics.

SPACE RESEARCH AND TECHNOLOGY

The objectives of the space research and technology program are to provide a technology base which will adequately support current and future space activities and to implement approaches for further reducing the

costs of future space activities through improvement of components. The **FY 1984** budget provides an increase in fundamental disciplinary research and technology. Emphasis on the longer term aspects of space technology is critical to future United States leadership in space.

In **FY 1984**, activities will focus on maintaining a strong research and technology base in the discipline areas of fluid and thermal physics, chemical propulsion, materials and structures, computer science and electronics, space energy conversion, controls and human factors, and space data and communications. In addition, activities in the research and technology base in spacecraft, transportation, and platform systems research are designed to study the interrelationships of discipline technology from an integrated systems point of view. These efforts are critical to the successful transition of technology from the laboratory to useful application. The systems technology effort in **FY 1984** will focus on the following technology missions or experiments: launch of the long duration exposure facility, the solar array flight experiment, solar cell calibration in-space facility, tribology experiment, reflight of the feature identification and location experiment, space test of an ion auxiliary propulsion system on a host vehicle, design activity on an in-space structures and controls experiment, and a cryogenic fluid management in-space facility.

TRACKING AND DATA ON

This program provides the vital tracking and data support required by all **NASA** flight projects in accomplishing their mission objectives. This support is currently provided by a worldwide network of **NASA** electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. In **1984**, the Tracking and Data Relay Satellite System (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions. The TDRSS contract has been restructured to provide for a dedicated government system to meet national space program requirements. A number of ground stations will be closed once the TDRSS is operational. Computation facilities also are provided to process into usable form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, ground instrumentation is provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

In **FY 1984**, funding will provide support to Space Shuttle flights and other ongoing spacecraft missions as well as preparation for approved upcoming missions. The request includes funds for TDRSS service, loan repayments, operations and maintenance of the tracking and data acquisition facilities, the engineering and procurement of equipment to sustain and modify the various systems to support continuing and new flight project requirements; and the investigation and development of advanced tracking and data acquisition systems and techniques.

IMPLEMENTATION OF PUBLIC LAW 97-219

In **FY 1983**, **NASA** will begin implementation of a research program utilizing only small business in compliance with P.L. 97-219, the "Small Business Innovation Development Act of 1982." The responsibility for developing implementing procedures and monitoring the program has been assigned to the Office of Aeronautics and Space Technology. The first solicitation of proposals is targeted for March 1983. The funding required will be drawn from the Research and Development appropriation.

The budget structure for the **FY 1984** Research and Development program has been revised from that used in **FY 1983**. However, the **FY 1982** and **FY 1983** columns in the tables supporting the **FY 1984** budget estimates have been adjusted for comparability of program content, and cross-walk exhibits showing the structural changes for each program area are provided in each applicable section.

The changes in the budget structure have been made for several reasons, including program realignments, a significant reorganization of the agency program offices and the change in the Space Transportation System program reflecting completion of the major portion of development activity, and to provide for a cleaner delineation of the program elements within the production/capability development and operations phase.

The following tables summarize the budget request in the new structure and compare this structure to the old structure for the **FY 1983** Budget Estimate column by authorization line item. The previous budget structure is shown across the down side and the amounts are those which appear in the column headed "Budget Estimate" under 1983. These are the amounts which would have shown in the **FY 1983** budget if it had been presented in the new structure. These figures provide a base against which the "current" estimate can be compared in terms of changes in estimates and program content. This same format is included in each major budget area.

STRUCTURE OF THE FY 1984 BUDGET

		1982	FY 1983		1984
		<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Code	Space Transportation	<u>3,089,850</u>	<u>3,467,800</u>	<u>3,597,800</u>	<u>3,498,000</u>
253	Capability development	<u>2,623,350</u>	<u>2,108,140</u>	<u>2,144,100</u>	<u>1,927,400</u>
	Operations	<u>466,500</u>	<u>1,359,400</u>	<u>1,453,700</u>	<u>1,570,600</u>
254	<u>SPACE SCIENCE AND APPLICATIONS</u>	<u>896,200</u>	<u>998,300</u>	<u>1,034,100</u>	<u>1,068,000</u>
254	Physics and astronomy.	<u>322,433</u>	<u>436,400</u>	<u>441,000</u>	<u>514,600</u>
254	Life sciences.....	<u>39,500</u>	<u>55,700</u>	<u>55,700</u>	<u>59,000</u>
254	Planetary exploration.....	<u>210,000</u>	<u>175,600</u>	<u>186,400</u>	<u>205,400</u>
254	Solid earth observations.....	<u>149,400</u>	<u>132,200</u>	<u>132,200</u>	<u>74,400</u>
254	Environmental observations.....	<u>133,023</u>	<u>156,500</u>	<u>156,900</u>	<u>163,000</u>
254	Materials processing in space.....	<u>16,244</u>	<u>22,000</u>	<u>22,100</u>	<u>21,600</u>
254	Communications.....	<u>21,300</u>	<u>12,400</u>	<u>32,400</u>	<u>21,100</u>
254	Information systems.....	<u>4,300</u>	<u>7,500</u>	<u>7,500</u>	<u>8,900</u>
254	<u>TECHNOLOGY UTILIZATION.....</u>	<u>8,000</u>	<u>1,000</u>	<u>91,000</u>	<u>4,000</u>
	<u>AERONAUTICS AND SPACE TECHNOLOGY</u>	<u>375,800</u>	<u>355,000</u>	<u>403,000</u>	<u>438,300</u>
402	Aeronautical research and technology..	<u>264,800</u>	<u>232,000</u>	<u>280,000</u>	<u>300,300</u>
254	Space research and technology.....	<u>111,000</u>	<u>123,000</u>	<u>123,000</u>	<u>138,000</u>
255	<u>TRACKING AND DATA ACQUISITION</u>	<u>402,100</u>	<u>508,900</u>	<u>498,900</u>	<u>700,200</u>
	Total	<u>4,771,950</u>	<u>5,334,000</u>	<u>5,542,800</u>	<u>5,708,500</u>

National Aeronautics and Space Administration

Research and Development
FY 1983 Congressional Budget Crosswalk
(Millions of Dollars)

Old Work Breakdown Structure	Total R&D	Space Shuttle	Space Flight Operations	Expendable Launch Vehicles	Physics & Astronomy	Planetary Exploration	Life Sciences	Applications	Technology Utilization	Aeronautics Research & Technology	Space Research and Technology	Tracking & Data Systems
	<u>5334.0</u>	<u>1718.0</u>	<u>1707.0</u>	<u>42.8</u>	<u>471.7</u>	<u>154.6</u>	<u>55.7</u>	<u>316.3</u>	<u>4.0</u>	<u>232.0</u>	<u>123.0</u>	<u>508.9</u>
New Work Breakdown Structure												
Space Trans. Capability Dev.	2108.4	1718.0	390.4									
Space Transportation Operations	1359.4		1316.6	42.8								
Physics & Astronomy	436.4				423.1			13.3				
Life Sciences	55.7						55.7					
Planetary Exploration	175.6				21.0	154.6						
Space Applications	330.6				27.6			303.0				
Technology Utilization	40								40			
Aeronautics R&T	232.0									232.0		
Space R&T	123.0										123.0	
Tracking & Data Acquisition	508.9											508.9

Summary of Changes:

Space Transportation Operations includes Shuttle Operations and Expendable Launch Vehicles. All other space transportation activities are included under Space Transportation Capability Development.

Planetary Exploration includes the International Solar Polar Mission which was previously included under physics and Astronomy.

Several adjustments have been made between Physics and Astronomy and Applications to better integrate related activities in research and analysis, operations and data analysis.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

For ~~necessary expenses~~, not otherwise provided for, including research, development, operations, ~~services~~, minor construction, maintenance, repair, ~~rehabilitation~~ and modification of ~~real~~ and personal property; tracking and data relay satellite services as authorized by law; purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; [and including not to exceed (1) \$1,769,000,000 for Space Shuttle, (2) \$1,796,000,000: *Provided*, That the amount available for obligation or expenditure shall be reduced to the extent subsequent authorizations provide for transfers for Space Flight Operations, (3) \$115,000,000 for Space Transportation Systems—Upper Stages, (4) \$88,000,000 for Space Transportation Systems Operations—Upper Stages, (5) \$137,500,000 for the Space Telescope, (6) \$34,500,000 for the Gamma Ray Observatory, (7) \$92,600,000 for Project Galileo, (8) \$4,000,000 for a Space Station, (9) \$55,000,000 for Performance Augmentation, without the approval of the Committees on Appropriations, \$5,542,800,000] *\$5,708,500,000*, to remain available until September 30. **[1984] 1985: [Provided, That \$280,000,000 shall be made available for aeronautical research and technology, that \$192,000,000 shall be made available for design, development, procurement, and other related requirements of liquid hydrogen-liquid oxygen upper stages (Centaur): *Provided further*, That none of the funds in this or any other Act shall be used for the development of a fifth space shuttle orbiter without the approval of the Committees on Appropriations]. (42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1983; additional authorizing legislation to be proposed.)**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1982 actual	1983 est.	1984 est.	1982 actual	1983 est.	1984 est.
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Capability development..	2,638,350	2,144,100	1,927,400	2,543,285	2,262,315	1,944,400
(b) Operations...	466,500	1,453,700	1,570,600	459,966	1,442,167	1,588,100
2. Scientific investigations in space:						
(a) Physics and astronomy..	322,400	441,000	514,600	333,045	484,335	514,600
(b) Planetary exploration.....	210,000	186,400	205,400	198,037	208,663	205,400
(c) Life Sciences.....	39,500	55,700	59,000	51,352	58,689	59,000
3. Space and terrestrial applications:						
(a) Space applications	324,300	351,000	289,000	318,983	397,618	289,000
(b) Technology utilization.....	8,000	9,000	4,000	8,083	10,191	4,000
4. Space research and technology.....	111,000	123,000	138,000	117,817	131,370	138,000
5. Aeronautical research and technology..	264,800	280,000	300,300	258,357	312,678	300,300
6. Energy technology	---	---	---	-17	17	---
7. Supporting activity:						
(a) Tracking and data acquisition.. .	402,100	498,900	700,200	382,573	532,562	700,200
Subtotal direct program.....	4,786,950	5,542,800	5,708,500	4,671,481	5,840,605	5,743,000
Program funded in R&D.....	48,950	---	---	---	---	---
Program funded in this account.....	<u>4,738,000</u>	<u>5,542,800</u>	<u>5,708,500</u>	<u>4,671,481</u>	<u>5,840,605</u>	<u>5,743,000</u>
Reimbursable program:						
1. Space transportation systems:						
(a) Capability development..	177,680	245,250	211,500	159,464	283,112	211,500
(b) Operations	373,947	451,600	473,400	47,865	507,274	473,400

Sum 13

Identification code 80-0108-0-1-999		Budget plan (amounts for research and development actions programed)			Costs and obligations		
		1982 actual	1983 est.	1984 est.	1982 actual	1983 est.	1984 est.
2.	Scientific investigations in space:						
	(a) Physics and astronomy.....	1,707	450	170	1,403	852	170
	(b) Planetary exploration.....	155	50	---	176	174	---
	(c) Life sciences.....	196	170	170	191	174	170
3.	Space and terrestrial applications:						
	(a) Space applications.....	111,144	92,850	115,170	403,640	136,121	115,170
	(b) Technoloty utilization.....	7,527	13,000	14,470	6,384	14,365	14,470
4.	Space research and technology..	5,062	1,450	1,250	4,971	1,680	1,250
5.	Aeronautical research and technology..	25,578	22,850	24,290	28,316	28,299	24,290
6.	Energy technology.....	140,104	123,500	97,800	117,730	164,183	97,800
7.	Supporting activity:						
	(a) Tracking and data acquisition..	43,171	21,300	21,500	39,175	26,959	21,500
	Total reimbursable program.....	<u>886,271</u>	<u>972,470</u>	<u>959,720</u>	<u>809,315</u>	<u>1,163,193</u>	<u>959,720</u>
10.00	Total obligations.....	5,624,271	6,515,270	6,668,220	5,480,796	7,003,798	6,702,720
	Financing:						
	offsetting collections from:						
11.00	Federal funds.....	-594,346	-779,865	-761,255	-560,775	-779,865	-761,255
14.00	Non-Federal sources.....	-291,925	-192,605	-198,465	-291,701	-195,605	-198,465
	unobligated balance available, start of year: For completion of prior year budget plans:						
21.40	Direct.....	---	---	---	-282,483	-347,305	-34,500
21.40	Reimbursable.....	---	---	---	-147,696	-190,723	---
23.40	Unobligated balance transferred other accounts.....	---	---	---	1,200	15,000	---
	Unobligated balance available, end of year: For completion of prior year budget plans:						

Sum 14

Identification code 80-0108-0-1-999		Budget plan (amounts for research and development actions programed)			Costs and obligations		
		1982 actual	1983 est.	1984 est.	1982 actual	1983 est.	1984 est.
24.40	Direct.....	---	---	---	347,305	34,500	---
24.40	Reimbursable.....	---	---	---	190,723	---	---
25.00	Unobligated balance lapsing.....	---	---	---	631	---	---
39.00	Budget authority.. ..	4,738,000	5,542,800	5,708,500	4,738,000	5,542,800	5,708,500
Budget Authority:							
40.00	Appropriation.....	4,740,900	5,542,800	5,708,500	4,740,900	5,542,800	5,708,500
41.00	Transferred to other accounts.....	-2,900	---	---	-2,900	---	---
43.00	Appropriation (adjusted).....	4,738,000	5,542,800	5,708,500	4,738,000	5,542,800	5,708,500
Relation of obligations to outlays:							
71.00	Obligations incurred, net.....				4,628,320	6,031,328	5,743,000
72.40	Obligated balance, start of year.....				1,267,945	1,096,699	1,793,027
74.40	Obligated balance, end of year.....				-1,096,699	-1,793,027	-1,931,027
77.00	Adjustments in expired accounts.....				-3,190	---	---
90.00	Outlays.....				4,796,376	5,335,000	5,605,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

<u>Code</u>		<u>FY 1982</u>	<u>FY 1983</u>	<u>FY 1984</u>
253	Space Flight	3,089,850	3,597,800	3,498,000
254	Space Science, Applications and Technology	1,015,200	1,166,100	1,210,000
255	Supporting Space Activities	<u>402,100</u>	<u>498,900</u>	<u>700,200</u>
(250)	Subtotal, General Science, Space and Technology	4,507,150	5,262,800	5,408,200
402	Air Transportation	<u>264,800</u>	<u>280,000</u>	<u>300,300</u>
	<u>Total</u>	<u><u>4,771,950</u></u>	<u><u>5,542,800</u></u>	<u><u>5,708,500</u></u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
<u>OFFICE OF SPACE TRANSPORTATION SYSTEMS</u>	1982	3,089,850	1,551,017	412,033	1,001,333	6,380	31,301	124	2,617	1,029	57,600	26,416
	1983	3,597,800	1,463,100	489,103	1,306,200	5,000	84,300	800	3,000	400	120,103	125,800
	1984	3,498,000	1,331,700	515,500	1,335,400	6,103	50,900	1,400	3,203	900	112,200	140,700
Capability Development	1982	2,623,350	1,477,684	403,479	654,059	6,380	3,701	75	2,617	229	57,600	17,526
	1983	2,144,100	1,092,400	141,900	676,300	5,000	2,900	800	—	400	120,103	104,300
	1984	1,927,400	943,300	160,600	580,400	6,103	1,500	1,400	—	900	112,203	121,000
Operations	1982	466,500	73,333	8,554	347,274	—	27,600	49	—	800	—	8,890
	1983	1,453,700	370,700	347,200	629,900	—	81,400	—	3,000	—	—	21,500
	1984	1,570,600	388,400	354,900	755,000	—	49,400	—	3,000	—	—	19,700
<u>OFFICE OF SPACE SCIENCE APPLICATIONS</u>	1982	896,200	38,903	3,333	185,480	3,514	290,471	189,409	72,859	10,016	16,740	85,475
	1983	1,034,100	48,566	6,490	254,903	2,144	326,818	185,056	62,968	9,466	25,466	112,223
	1984	1,068,000	39,071	8,650	244,527	1,081	352,167	213,556	61,426	9,586	11,850	126,066
Physics and Astronomy	1982	322,433	4,985	2,225	171,180	—	87,863	19,309	17,230	122	—	19,519
	1983	441,000	8,500	5,035	239,529	—	120,567	18,243	19,345	28	—	29,783
	1984	514,600	8,650	7,100	229,816	—	194,523	20,554	21,593	18	—	32,346
Life Sciences	1982	39,500	12,742	938	72	—	—	1,136	17,048	253	—	7,311
	1983	55,703	19,221	1,485	250	—	80	1,028	22,037	421	—	11,208
	1984	59,000	20,032	1,550	267	—	86	1,102	23,128	452	—	12,383
Planetary Exploration	1982	210,000	6,887	—	143	—	3,921	132,936	33,551	—	—	32,562
	1983	186,400	7,307	—	—	—	5,483	120,158	17,136	—	—	36,316
	1984	205,400	6,800	—	—	—	4,336	139,040	12,253	—	—	42,971
Space Applications	1982	324,267	14,289	170	14,085	3,514	198,687	36,028	5,030	9,641	16,740	26,083
	1983	351,000	13,538	—	15,124	2,144	200,688	45,627	4,480	9,017	25,466	34,916
	1984	289,000	3,589	—	14,444	1,081	153,242	52,860	4,452	9,116	11,850	38,366
<u>TECHNOLOGY UTILIZATION</u>	1982	8,000	25	25	235	20	630	471	75	597	40	5,882
	1983	9,000	—	250	265	20	999	743	138	771	312	5,502
	1984	4,000	—	55	195	—	380	265	105	435	240	2,325
<u>OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY</u>	1982	375,800	8,550	100	11,600	—	10,300	22,500	96,800	118,000	100,750	7,200
	1983	403,000	13,200	150	13,500	—	10,650	22,500	106,000	122,300	105,000	9,703
	1984	438,300	14,700	300	15,203	—	11,103	24,000	133,703	123,800	105,500	10,000
Aeronautical research and technology	1982	264,800	150	—	700	—	500	500	86,000	93,000	79,750	4,200
	1983	280,000	200	—	500	—	500	500	96,000	94,300	83,000	5,000
	1984	300,300	—	—	600	—	500	500	122,200	95,300	78,000	5,000
Space research and technology	1982	111,000	8,000	100	10,900	—	9,800	22,000	10,000	25,000	21,000	3,000
	1983	123,000	13,000	150	13,000	—	10,150	22,000	10,000	28,000	22,000	4,700
	1984	138,000	14,500	300	14,600	—	10,600	23,500	11,500	30,500	27,500	5,000
<u>OFFICE OF SPACE TRACKING AND DATA ACQUISITION</u>	1982	402,100	—	—	1,321	—	281,935	103,680	2,925	—	—	12,239
	1983	498,900	—	—	2,400	—	317,600	110,600	4,203	—	—	64,103
	1984	700,200	—	—	13,000	—	360,100	106,900	6,600	—	—	213,600
TOTAL BUDGET PLAN	1982	4,771,950	1,598,495	415,491	1,199,969	9,914	614,637	316,184	175,276	129,642	175,130	137,212
	1983	5,542,800	1,524,866	495,990	1,577,268	7,164	740,367	319,699	176,306	132,937	250,878	317,325
	1984	5,708,500	1,385,471	524,505	1,608,322	7,181	774,667	346,121	205,031	134,721	229,790	492,691

Sum 17

SPACE
TRANSPORTATION
PROGRAMS

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1984 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE TRANSPORTATION SYSTEMS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget Estimate (Thousands of Dollars)	Current Estimate (Thousands of Dollars)	<u>1984</u> Budget Estimate	<u>Page</u> <u>Number</u>
<u>Space Transportation Capability</u>					
<u>Development</u>	<u>2,623,350</u>	<u>2,108,400</u>	<u>2,144,100</u>	<u>1,927,400</u>	
Shuttle DDT&E.....	894,000	---	---	---	
shuttle production and capability development.....	1,282,750	1,744,500	1,729,300	1,500,000	RD 1-8
Upper stages.....	106,700	95,000	167,000	143,200	RD 1-24
Spacelab.....	100,800	113,200	121,200	119,600	RD 1-27
Engineering and technical base.....	183,100	82,400	70,300	93,100	RD 1-30
payload operations and support equipment.....	46,300	61,400	44,400	53,200	RD 1-33
Advanced programs.....	9,700	11,900	11,900	15,000	RD 1-35
Tethered satellite system.....	---	---	---	3,300	RD 1-37
<u>Space Transportation Operations</u>	<u>466,500</u>	<u>1,359,400</u>	<u>1,453,700</u>	<u>1,570,600</u>	
Shuttle Operations	435,300	1,316,600	1,370,700	1,520,600	RD 2-5
Flight operations.....	(71,300)	(314,200)	(330,100)	(315,000)	RD 2-8
Flight hardware.....	(357,600)	(659,200)	(692,100)	(848,400)	RD 2-10
Launch and landing operations....	(6,400)	(343,200)	(348,500)	(357,200)	RD 2-12
Expendable Launch Vehicles	31,200	42,800	83,000	50,000	RD 2-12
Delta.....	(30,400)	(42,800)	(83,000)	(50,000)	
sat.....	(800)	(---)	(---)	(---)	
Total Space Transportation Systems....	<u><u>3,089,850</u></u>	<u><u>3,467,800</u></u>	<u><u>3,597,800</u></u>	<u><u>3,498,000</u></u>	

OFFICE OF SPACE FLIGHT
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

	SPACE TRANSPORTATION SYSTEM	Space Shuttle	Orbiter	Main Engine	Launch & Landing	Spares & Equipment	Performance Augmentation	Changes & Systems Upgradi	Space Flight Operations	STS Operations Capability Dev.	STS Operations	Other Space Flight Operation	Expendable Launch Vehicles
<u>Old Structure</u>	<u>3467.8</u>	<u>1718.0</u>	933.5	262.0	67.0	323.0	60.0	72.5	<u>1707.0</u>	85.4	1414.1	207.5	<u>42.8</u>
<u>New Structure</u>													
<u>SPACE TRANSPORTATION CAPABILITY DEVELOPMENT</u>	<u>2108.4</u>	<u>1718.0</u>	(933.5)	(262.0)	(67.0)	(323.0)	(60.0)	(72.5)	<u>390.4</u>	(85.4)	(97.5)	(207.5)	
Shuttle Production & Capability Development	1744.5												
Orbiter	924.6												
Production & Support	740.5		734.8				5.7						
Sys. Integration	68.9		68.9										
Orbiter Spares	115.2					115.2							
Launch & Mission Support	245.4												
Launch Site Equipment	69.0				67.0	1.5	.5						
Mission Support Cap.	121.6		83.6			34.0				4.0			
Mission Ops. Cap.	54.8		32.3							22.5			
Propulsion Systems	502.0												
Main Engine	285.7			262.0		23.7							
Solid Rocket Booster	86.8					33.0	53.8						
External Tank	115.6					115.6							
Systems support	13.9		13.9										
Changes & System Upgrading	72.5							72.5					
Upper Stages	95.0												
Development	32.0									32.0			
Operations	63.0										53.0		
Spacelab	113.2											113.2	
Engineering & Tech. Base	82.4											82.4	
Payload Ops. & Supt. Equip.	61.4												
Payload Operations	34.5										34.5		
Support Equipment	26.9									26.9			
Advanced Programs	11.9											11.9	
<u>SPACE TRANSPORTATION OPERATIONS</u>	<u>1359.4</u>								<u>1316.6</u>		(1316.6)		(42.8)
Shuttle Operations	1316.6												
Flight Operations	314.2												
Mission Operations	121.3											121.3	
Integration	150.6											150.6	
Support	42.3											42.3	
Flight Hardware	659.2												
Orbiter	141.5											141.5	
Solid Rocket Booster	244.2											244.2	
External Tank	273.5											273.5	
Launch & Landing Ops.	343.2												
Launch Operations	297.0											297.0	
Launch Support	46.2											46.2	
Expendable Launch Vehicles	42.8												42.8

SPACE TRANSPORTATION
CAPABILITY
DEVELOPMENT

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Shuttle DDT&E.....	894,000	---	---	---	
Shuttle production and capability development.. ..	1,282,750	1,744,500	1,729,300	1,500,000	RD 1-8
Upper stages.....	106,700	95,000	167,000	143,200	RD 1-24
Spacelab	100,800	113,200	121,200	119,600	RD 1-27
Engineering and technical base.. ..	183,100	82,400	70,300	93,100	RD 1-30
Payload operations and support equipment	46,300	61,400	44,400	53,200	RD 1-33
Advanced programs.....	9,700	11,900	11,900	15,000	RD 1-35
Tethered satellite system.....	---	---	---	3,300	RD 1-37
Total.....	<u>2,623,350</u>	<u>2,108,400</u>	<u>2,144,100</u>	<u>1,927,400</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center	1.477. 684	1,161,600	1.092. 400	943. 300
Kennedy Space Center	403,479	109,400	141. 900	160,600
Marshall Space Flight Center	654. 059	689,600	676,300	580. 400
National Space Technology Laboratories	6,380	4. 800	5. 000	6. 100
Goddard Space Flight Center	3. 701	6. 700	2,900	1.500
Jet Propulsion Laboratory	75	---	800	1. 400
Ames Research Center	2. 617	5. 000	---	---
Langley Research Center	229		400	900
Lewis Research Center	57. 600	---	120,100	112,200
Headquarters	<u>17. 526</u>	<u>131. 300</u>	<u>104,300</u>	<u>121. 000</u>
 Total	 <u>2.623, 350</u>	 <u>2.108. 400</u>	 <u>2,144,100</u>	 <u>1.927. 400</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE FLIGHT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national and international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space applications, scientific, and national security payloads. The Space Shuttle offers unique capabilities that cannot be achieved with today's expendable launch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions.

Shuttle production and capability development provides for the national fleet of Space Shuttle orbiters, including main engines, and provides for the launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities to meet appropriate national needs. More specifically, this line item contains the orbiter production contract for the second, third, and fourth flight orbiters, the changeover of the first orbiter into its operational configuration, and the provisions for procurement of spare orbiter structural components; the continuing capability development tasks for the orbiter, main engine, external tank (ET) and solid rocket booster (SRB); the provision of the second line of processing stations and equipment for launch and landing; the development of the filament wound case (FWC) solid rocket booster; the lay-in of spares and the ground support equipment; and the production rate tooling for the ET and SRB. Equipment modifications to two orbiters, mobile launchers, and launch pads for the 1986 launches of the Centaur as a Space Transportation System upper stage are also funded under this budget item. The second phase of development of the Mission Control Center (MCC Level 11), operations effectiveness studies, and changes and systems upgrading are also provided for under Shuttle production and capability development.

The upper stages program includes the effort necessary to provide upper stages for use with the Space Shuttle to place payloads in orbits and trajectories beyond the capability of the Shuttle alone, primarily for planetary and geosynchronous missions. Current developments include the two-stage configuration of the Inertial Upper Stage (IUS), and the modification of the Centaur for use in the Shuttle.

The engineering and technical base provides the core capability for the engineering, scientific, and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for Space Transportation Systems research and development activities.

The Spacelab is a major element of the STS and provides a versatile, reusable laboratory which will be flown to and from Earth orbit in the Shuttle orbiter cargo bay. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of the Spacelab development effort includes hardware and system activation efforts which assure Spacelab compatibility with the orbiter, leading to an operational capability.

Payload operations and support equipment provides for developing and placing into operational status the ground and flight systems necessary to support the NASA payloads during pre-launch processing, on-orbit mission operations, and, when appropriate, post-landing processing.

The advanced programs effort identifies potential future space programs and provides technical as well as programmatic data for their definition and evaluation. In support of this effort, advanced development activities are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology. Key elements of this activity are the numerous system trade studies related to space stations.

The Tethered Satellite System (TSS) will provide a new capability for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. This program will be undertaken in conjunction with the Italian government.

STATUS

The orbiter production activities provide for the completion of fabrication and delivery of the four-orbiter fleet. Columbia (OV-102) was used to fly the four orbital flight tests and first operational mission; Challenger (OV-099) is at KSC preparing for its first mission (STS-6); and, Discovery (OV-103) and Atlantis (OV-104) are scheduled for delivery in September 1983 and December 1984, respectively. Progress on OV-103 and OV-104 to date indicates that the planned delivery dates can be achieved. Modifications to enable the launch of the Centaur upper stage on OV-099 and OV-104 are underway; the modification kits will be installed in FY 1986. The Columbia (OV-102) is now undergoing a period of modification at KSC in order

to prepare the vehicle for the launch of the first Spacelab mission, currently planned for September 1983. The Columbia will be modified to full operational configuration in FY 1985, although these modifications may be rescheduled for an earlier date pending an evaluation of the training and vehicle processing requirements associated with maintaining orbiters having two different configurations. Orbiter spares procurements to establish the required level of spares availability at the KSC launch site are continuing, and close attention is being given to the estimated spares requirements as a function of the experience being gained during operations. The Administration has authorized the inclusion in this budget request of the amounts required to procure extensive spares to ensure the operational viability of four-orbiter fleet; initiation of procurement is planned for FY 1983.

At KSC the second line of vehicle processing stations is being phased in to support launch processing of two or more orbiters simultaneously. The second mobile launcher platform was brought on-line in August 1982 and the second bay of the orbiter processing facility became operational in June 1982. The second set of high bays in the vehicle assembly building (VAB) will be ready for operations in the summer of 1983, the launch processing systems's software production capability and second firing room will be ready in the fall of 1983, and the SRB processing and storage facility will be available in early 1984. The second launch pad (Pad B) is now planned to be operational in January 1986, consistent with the requirements to support the launches of the Galileo and International Solar Polar Mission (ISPM) in May-June 1986. The third mobile launcher platform, on which design work was initiated in 1982, is planned for a September 1986 readiness date. Modifications to the mobile launcher platforms (MLP-1 and MLP-2) and to launch pad systems to be compatible with the use of the Centaur as a Shuttle upper stage were authorized in 1982 and the design work is underway.

Development testing and production continue on the Space Shuttle main engine (SSME) in its full power level (FPL) configuration. Production engine delivery schedules have been adjusted to permit the changeout of the Columbia's rated power level engines after the fifth flight (instead of the ninth flight) and for the addition of an engine (2027) to the production sequence to replace engine 2013, destroyed in an early FPL certification test. Engine test incidents in 1982 indicated the need for additional hardware fabrication to support the on-going FPL test schedules. Replacement of the hardware lost during the past year and provisions for long-lead hardware to support the ground test program are reflected in the current estimates for FY 1983 and in the FY 1984 request. On the positive side, however, the performance of the main engines in their first five flights has validated the concept of a reusable rocket engine having high thrust capability.

The experience with the SRB's during the initial flights has revealed the need for design improvements to reduce the amount of water impact damage to the SRB's aft end, particularly to the hydraulic power units

mounted internally to the aft skirt. Interim fixes have been pursued, resulting in reduced damage to the SRB's on STS-5. Work is underway on new designs to provide a long-term solution.

The ET performance on its first five flights was excellent. The delivery of the new lightweight tank was made on schedule and with greater weight savings than initially baselined. The first flight of the lightweight tank is planned for STS-6. Emphasis continues on the cost-reduction/producibility/production readiness efforts to identify and implement the associated flow and processing improvements anticipated in the projections of operational tank costs and required to meet the increasing production build rates. Rate tooling for both the ET and SRB is based on supporting a flight rate of 24 per year, although the planning is based on maintaining a capability to increase production above that rate. Effort continues to identify "choke points" where additional tools or cells will be required at the Michoud Assembly Facility to meet the current capability requirement. Preliminary reviews indicate that additional tools and equipment will be necessary in a number of manufacturing areas; the preliminary findings will be defined in detail along with the implementation schedule and funding requirements. Based on fabrication and flight experience, there is a reduction in the amount of super lightweight ablator (SLA) required on the tank, and a number of SLA application tools have been eliminated.

The development of the filament wound case (FWC) for the SRB has been initiated to improve the performance of the Space Shuttle for high performance missions. The filament wound case contractor has been selected. The expected weight reduction in the SRB by using the FWC in place of the steel cases is estimated at 66,000 pounds, resulting in a payload capability improvement of approximately 5,500 pounds. Integration analyses were started in 1982 to determine the loads effect on the orbiter and the ET and to analyze the lift-off loads induced by the launch platform at the Vandenberg launch site.

In upper stages, a joint development program with the DOD, has been initiated for the use of the Centaur as a STS upper stage. The Centaur/STS will be a wide-body derivative of the Centaur stage used in the Atlas-Centaur program. The common vehicle, designated Centaurs, will accommodate a 40-foot long, approximately 10,000-pound payload in the bay of the orbiter, and be capable of placing it into geosynchronous orbit. A longer version of the Centaurs, known as G-prime, is being developed by NASA for planetary missions. The Air Force and NASA will equally share common design and development costs for the Centaurs. An agreement on the Centaur was signed by the Air Force and NASA in November 1982. The Centaur-G-prime will be first used for launching the Galileo and ISPM spacecraft in 1986, replacing the previously planned planetary version of the Inertial Upper Stage (IUS).

Another adjustment to the IUS production program will result in a reduction in the number of vehicles delivered to NASA for the launch of the Tracking and Data Relay Satellites (TDRSS). As a result of the

restructuring of the Tracking and Data Relay Satellite System (TDRSS) service agreement to make the TDRSS a dedicated Government system, the near-term requirement for IUS vehicles to support the TDRSS launches has been reduced from six vehicles to four. The Air Force is planning to complete the two vehicles no longer required by NASA and to assign them to DOD missions. The initial launch of the TDRS/IUS on the Shuttle is planned on STS-6. Two additional spacecraft will be launched to complete the TDRSS in-orbit constellation. A ground spare spacecraft and IUS vehicle will be maintained to provide the capability to replace an orbital spacecraft in the event of a spacecraft failure.

The initial Spacelab flight units (module, pallets, and igloo) and ground support equipment were delivered by the ESA in 1982. The first crew transfer tunnel, a U.S. development responsibility, was delivered to KSC in December 1982. Fabrication of the verification flight instrumentation for the initial Spacelab mission has now been completed, and integration of the software for the Spacelab simulator being used in training for this mission was also completed. Preparations for the flight of Spacelab-1 in September 1983 are well underway.

In advanced programs, mission analysis studies are in process for a possible future space station. A space station task force has been formed within NASA to review the merits and technical feasibility of establishing a permanent manned presence in space. Contractor mission analyses were initiated in 1982, and preliminary reports have been made by the contractor teams; final reports will be completed in mid-1983. In other advanced programs areas, the advanced development of the Tethered Satellite System will continue, leading to the proposed initiation of hardware development in FY 1984. Preliminary definition of advanced transportation vehicle concepts, including orbital transfer vehicles, teleoperator maneuvering vehicles, and Shuttle-derived launch vehicles, is also being conducted. Work is proceeding on the investigation of advanced systems, tools, and techniques for placement, retrieval, and maintenance/repair of spacecraft.

In payload operations and support equipment, payload integration support and payload-related hardware are developed and furnished for NASA payloads. A key activity currently underway is the support of the retrieval/repair mission for the Solar Maximum Mission spacecraft, which is being undertaken with funding supplied by both NASA and the DOD. This mission is currently planned for mid-1984. Multi-mission payload equipment being developed includes a payload bay bridge structure to carry small payloads, apparatus for providing cooling of the heat generated in the orbiter bay by the radioisotope thermal generators (RTG's) used for planetary missions, and a standard mission cable wire harness for mixed cargos. The Payload Operations Control Center (POCC) at JSC is presently being readied to support the operations of the Spacelab-1 mission in September 1983.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**SHUTTLE PRODUCTION AND CAPABILITY DEVELOPMENT**

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of	Dollars)		
Orbiter.....	916,850	924,600	904,400	729,600	RD 1-11
Launch and mission support.....	134,900	245,400	246,600	245,500	RD 1-15
Propulsion systems.....	231,000	502,000	553,300	472,200	RD 1-18
Changes and systems upgrading	<u>---</u>	<u>72,500</u>	<u>25,000</u>	<u>52,700</u>	RD 1-22
Total.....	<u>1,282,750</u>	<u>1,744,500</u>	<u>1,729,300</u>	<u>1,500,000</u>	

OBJECTIVES AND STATUS:

The objectives of this program are to provide for: the completion of the national fleet of Shuttle orbiters; the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and, the potential changes and upgrading to the Space Transportation System.

The planned four-orbiter fleet includes: Columbia (OV-102), the orbiter vehicle developed under the Space Shuttle design, development, test and evaluation (DDTCE) program and used for the first five flights; Challenger (OV-099), the second flight orbiter, which was fabricated using elements of the DDT&E structural test article; and two orbiters--Discovery (OV-103) and Atlantis (OV-104)--which are in production now and are of a lighter-weight configuration. The planned delivery dates for the two vehicles in production are September 1983 for OV-103 and December 1984 for OV-104. OV-102 is undergoing modifications at KSC in order to prepare the vehicle for the launch of the first Spacelab mission in September 1983. The final phase of modifications for OV-102 is now planned for FY 1985; these modifications may be rescheduled for an earlier date. OV-099 was delivered to KSC on schedule in July 1982, and is undergoing final checkout prior to its first launch in early 1983. Work was initiated in FY 1982 on the modifications to the orbiter and the related systems integration analyses for the use of the Centaur as a Shuttle upper stage. Two orbiters--OV-099 and OV-104--will be modified to carry the Centaur and its payloads. The provisioning of orbiter spares

is an on-going activity to support the requirements for the initial lay-in of line replaceable units of equipment at the launch site. In addition, the budget provides for the extensive acquisition of orbiter structural spares to support the four-orbiter fleet.

Launch and mission support provides for augmentations to the first line of processing stations at the KSC; the additional astronaut training, mission preparation and mission operation capabilities required for higher flight rates; the modifications to the launch site capabilities to accommodate the new Centaur upper stage; and, studies and analyses of program level improvements for the operations and management of the STS. The first line of KSC facilities (funded under Space Shuttle DDT&E) supported the launch processing and checkout of one orbiter vehicle from landing through launch. The second line of processing stations will support launch processing and checkout of two or more orbiters simultaneously, and will allow the east cost launch traffic to increase to 17 flights in FY 1987. A third Shuttle training aircraft will be acquired to support increased training requirements and permit the existing two aircraft to be overhauled when fatigue considerations make this necessary. The upgrading of the Mission Control Center (MCC) provide for reconfiguration of the JSC Mission Control Center to support two, and finally three, simultaneous orbiter operations (flights, tests, or simulations).

Propulsion system provide for the continued production and ground testing of the Space Shuttle main engines, for production rate tooling and equipment for the SRBs and ETs, for systems support to the main propulsion tests of the main engines, and for the development of the filament wound composite motor case for the SRB. Funding for the FWC and related integration analyses (such as liftoff and initial flight phase structural loads analyses) is included in Shuttle production and capability development at \$7.0 million in FY 1982, \$55.0 million in FY 1983, and \$80.1 million in FY 1984. In addition, the propulsion systems area continues to fund the design and development of improvements to the SRB to minimize flight and water impact damage, and for producibility and production readiness activities supporting the fabrication of the ET.

Changes and systems upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements. Examples of the use of such provisions recently include the initiation of work on the thrid mobile launcher platform in FY 1982 and FY 1983, for the third Shuttle training aircraft in FY 1983, and for the procurement of additional main engine hardware to replace hardware damaged or destroyed in ground engine testing.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The reduction of \$15.2 million in the current estimate from the budget estimate reflects the net effect of: the reprogramming of \$40.2 million to expendable launch vehicles for the additional funding requirements of the Delta launch vehicle; the addition of \$57.6 million for modifications to the orbiters, launch site capabilities, acceleration of the Pad-B readiness date, and integration analyses for the use of the Centaur as a Shuttle upper stage; a reduction of \$10 million in changes and system upgrading as part of the general reduction made by the Congress in the NASA research and development appropriation; a reduction of \$5.0 million in performance augmentation, consistent with the Congressional reduction made for this activity; and the reallocation of funding for the non-recurring development tasks for the Solar Maximum Mission spacecraft's retrieval and repair to the payload operations and support equipment budget line to consolidate the non-recurring and recurring costs for this mission. A number of other internal program funding adjustments have been made within the funding available for Shuttle production and capability development; these changes are addressed in the following material.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	1982 <u>Actual</u>	<u>ORBITER</u> 1983		1984 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of	<u>Current Estimate</u> Dollars)	
Orbiter production	828,150	740,500	729,800	464,700
Systems integration	30,300	68,900	59,700	62,900
Orbiter spares.....	<u>58,400</u>	<u>115,200</u>	<u>114,900</u>	<u>202,000</u>
Total.....	<u>916,850</u>	<u>924,600</u>	<u>904,400</u>	<u>729,600</u>

OBJECTIVES AND STATUS:

The objective of this program is to continue the orbiter production activities for OV-103 and OV-104 and related supporting efforts to meet the needs of NASA, the DOD, and other domestic and international users. The reusable orbiter is a key element in the STS, providing reliable, efficient and economical access to space. OV-099 was delivered on schedule to KSC in July 1982, and is now undergoing final checkout prior to its first launch in early 1983. With this delivery, there are now two vehicles in flow at KSC. OV-102 completed its fifth flight in November 1982, which marked the beginning of operational activities as it placed two commercial satellites into orbit.

Columbia (OV-102) is now undergoing a period of modification at KSC in order to prepare the vehicle for the launch of the first Spacelab mission in the fall of 1983. The final phase of modifications for OV-102 currently planned for FY 1985 will bring this orbiter into a fully operational configuration. However, as the problems of operating two orbiters in different configurations become better understood, it may be necessary to move these final modifications forward to FY 1984.

The Shuttle production program is progressing toward the planned delivery of the third orbiter, OV-103, in September 1983. Major elements of OV-103 have been delivered to Palmdale for final assembly. These include the mid fuselage, elevons, wings, vertical tail, and lower forward fuselage. Through January 1983, over 10,000 tiles will have been installed. The OV-103 effort is progressing satisfactorily and the current status of manufacturing and checkout is consistent with the planned September 1983 delivery. The delivery

date for OV-104 remains December **1984**. Subcontractor deliveries on OV-104 are already occurring and will be **80** percent complete at the end of FY **1983**. Maintenance of the OV-103 and the OV-104 delivery dates is consistent with the orbiter allocation plans for meeting the initial operational capability date for the Vandenberg Air Force Base launch site in October **1985**.

The modifications to the orbiter for carrying the Centaur as an upper stage are currently in the design phase. Orbiter ground support equipment and modification kit designs will undergo a preliminary design review in early **1983** and a Critical Design Review in late **1983**. Procurement of the necessary propellant servicing quick disconnects has been initiated. Modification kits for the two orbiters should be completed by early **1985**.

Systems integration activities being conducted include the assessment of the lift-off and initial flight phase structural loads for new system elements, particularly for the impact of the filament wound case for launches from Vandenberg: the flight-by-flight performance margin assessments; post-flight performance and anomaly analysis and reconstruction; turnaround reduction analyses; contingency abort analyses; and Vandenberg systems integration. The analyses of the system level verification and integrated testing requirements for the Centaur upper stage represent a major activity within systems integration to assure that the Centaur can be safely and effectively integrated into the STS.

The procurement and fabrication of orbiter spares continues. Maintenance requirements analyses for line replaceable units are underway at the prime contractor's plant and at subcontractor facilities. These analyses are based on test and flight experience, and form the basis for deciding the timing of the spares procurements. These spares cover not only avionics units (such as flight computers), but also mechanisms (e.g., payload door latches, actuators, and power drive units) and propulsion systems (reaction control system engines and orbit maneuvering system engines).

Procurement of additional structural assemblies and components for the orbiter has been authorized by the Administration to ensure the long term operational viability of the four-orbiter fleet by providing the capability to repair or replace structural components in the event of damage to those components. Procurement of these assemblies will be initiated in FY **1983** after the receipt of the prime contractor's proposal and **NASA's** review and approval. This action will also reduce the lead time for expansion or replacement of the four-orbiter fleet when operational demands of the Space Transportation System so require. Major structural assemblies and selected structural parts are planned to be fabricated. Structural parts include the rudder, elevons, speed brake, landing gear, and landing gear doors. Major

structural assemblies include the wings, aft thrust structure engine compartment, crew module (including the nose and cockpit), mid and aft fuselage sections, payload bay doors, vertical tail and the orbital maneuvering system pods. All of the major structural assemblies will be completed up to the point where they would be ready for installation of the thermal protection system, plumbing, wire harnesses, and major electrical, propulsion, and hydraulic components.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

There are several changes from the FY 1983 budget request to the current estimate, totalling to a net decrease of \$20.2 million. The first is the inclusion of funds to procure major structural components to be used as spares for the current fleet. To some extent, this added requirement is offset by deferral of piece parts and short lead time spares to FY 1984 and FY 1985. The second is the decision to make interim modifications to Columbia (OV-102) to prepare it for the first Spacelab flight in September 1983; the baseline plan had been to make the required full-up modification after STS-5. This modification is now planned for FY 1985, although it may be moved forward to FY 1984. This decision was required in order to hold the Spacelab-1 mission date. The third change results from the modifications to the orbiter vehicles and necessary system integration analysis to use the Centaur upper stage with the Shuttle. The current estimate also reflects a decrease in systems integration engineering manpower due to the success of the orbital flight test (OFT) program. In addition, production parts for the orbiter were accelerated from FY 1983 to FY 1982 to reduce the schedule risks on OV-103 and OV-104; a fifth cryogenic tank was added to OV-102 to allow extension of the first Spacelab on-orbit time by 2-3 days; and the payload bay kit for the orbital maneuvering system which was originally planned for the Solar Maximum Mission retrieval/repair was deleted as a mission requirement in January 1982 after the submission of the FY 1983 budget estimates.

BASIS OF FY 1984 ESTIMATE:

A major effort in FY 1984 will be the completion of the final stages of manufacturing on OV-104 at the Rockwell Palmdale facility, including final assembly and integrated testing, leading to its delivery in December 1984. FY 1984 funding is also being requested to provide for procurement of major structural components as spares for the orbiter fleet. These structural components will include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These items will be assembled into varying stages of completion so that they can be used as structural spares for the current fleet. FY 1984 funding will also be utilized for performance augmentation activities primarily to conduct orbiter loads analyses in support of the filament wound case (FWC) development program, and for modification of OV-099 and OV-104 to accept, boost, and deploy the wide-bodied Centaur upper stage. Ground support equipment and test hardware are also provided to support KSC activities.

In FY 1984, systems integration activities will be concentrated on the engineering analysis and integration support for vehicle capability changes as the Space Shuttle performance improvements (such as the filament wound case) are brought into the program: support to STS cargo operations and the flight program, including the investigation/resolution of flight problems; and support of the Vandenberg launch site activation.

Logistics support to the Space Shuttle program requires the lay-in of orbiter and main engine spares and ground support equipment needed for replacement of Shuttle components and for support to ground processing operations as the fleet size and flight rate increase. Projected failure rates for each item, and turn-around times for repairs are two significant factors in determining the quantity of spares to be procured. The funding for orbiter spares covers not only the cost of orbiter flight spares and ground support equipment spares, but also the logistics support to analyze requirements and procure these spares.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

LAUNCH AND MISSION SUPPORT

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Launch site equipment	67,300	69,000	101,300	107,400
Mission support capability	35,700	121,600	91,000	75,100
Mission operations capability	<u>31,900</u>	<u>54,800</u>	<u>54,300</u>	<u>63,000</u>
Total.....	<u>134,900</u>	<u>245,400</u>	<u>246,600</u>	<u>245,500</u>

OBJECTIVES AND STATUS:

The first line of stations previously activated at KSC supports the launch processing and checkout of one orbiter vehicle from landing through launch. The second line of stations is being phased in to support launch processing of two or more orbiters simultaneously. The second high bay of the orbiter processing facility and the second mobile launcher platform (MLP) became operational in June 1982 and August 1982, respectively, to provide parallel processing of OV-099 and OV-102 through the first portion of two processing lines. Other stations to be activated in the "second line" include a second set of high bays in the VAB, a second launch pad, a SRB processing facility, a ground software production capability, a second operational firing room, and a third MLP. The changes to the launch pads, MLPs, and supporting elements to enable the use of the Centaur upper stage have been initiated. The second launch pad activation schedule has been accelerated from September 1986 to January 1986 in accordance with the station need dates to support the two planetary launches in 1986.

Also under launch and mission support are the procurement and modification of a third Gulfstream II for use as a Shuttle training aircraft, the fabrication of the manned maneuvering units and extra-vehicular mobility units (space suits), and other mission support activities for training and simulations. These activities include the operations of the Shuttle engineering simulation system, the modifications to the Shuttle mission simulator, the operations of the data reduction center, procurement of TACAN ground stations, changes to systems supporting the Shuttle mission simulator to provide more rapid mission-to-

mission reconfigurations of the training software, and support of post-OFT development test objectives. The two manned maneuvering unit flight articles are scheduled for delivery in January and July of 1983. It has been decided to limit the extra-vehicular mobility unit procurement quantities by reducing the number of sizes to provide for medium and large sizes only. The Shuttle training aircraft has been identified by the JSC personnel responsible for crew training as being of great importance in assuring crew familiarity with the orbiter's handling characteristics prior to landing; a third Shuttle training aircraft is required to meet crew training requirements in light of the eventual need for overhaul of the present two aircraft when fatigue considerations prompt this change.

Within launch and mission support are the operations effectiveness effort and the Mission Control Center upgrading (Level 11). Operations effectiveness is a program evaluation activity intended to identify those program level improvements in operating and managing the STS which would improve the overall effectiveness of the system.

The Mission Control Center upgrading (Level 11) will provide for the reconfiguration of the MCC at JSC to support the STS's operational flight schedule requirements. The use of additional hardware, equipment, and software to operate the MCC will provide for systems monitoring and flight control capability in support of two, and later three, simultaneous operations (flight, test or simulation). Funds are required to complete the flight control room on the second floor of the MCC and initiate capability development for three vehicle operations. The major milestone for the higher flight rate capability is two-vehicle capability in April 1984.

CHANGES FROM FY 1983 BUDGET :

The current estimate is \$1.2 million more than the budget estimate. The significant increase in launch site equipment is due principally to the changes required to support the launches of the Galileo and ISPM in 1986 utilizing the Centaur upper stage. This program redirection necessitated the advancement of the Pad-B operational readiness date from September 1986 to January 1986, the modifications of both launch pads and MLPs, and the related changes to other launch processing systems. Other changes now incorporated in the current estimate include the initiation of work on the third MLP, the addition of the Spacelab-1 mission modification changes to OV-102 (Columbia), and increased funding requirements for the Shuttle inventory management system. These increases have been partially offset by revised manpower estimates for site activation, deferral of equipment procurements based on reassessments of need dates, and the application of program reserves.

The reduction in mission support capability reflects the change in program flexibility to meet new program requirements in accordance with the need to reprogram FY 1983 funding from Shuttle production and capability development to the Delta. In addition, the non-recurring costs to support the retrieval and repair of the Solar Maximum Mission spacecraft have been reallocated to payload operations and support equipment as previously addressed.

In mission operations capability, funding for the initial phase of work on the third Shuttle training aircraft has been allocated from within this program element due to reductions in the amount of post-OFT analyses required.

BASIS FOR FY 1984 ESTIMATE:

Several major activities will be underway during FY 1983, including the final installation and activation of VAB high bay cells 1/2 and the launch processing software development system to meet the FY 1983 operational readiness dates. This work phases into the facilities (funded under Construction of Facilities appropriation) being completed, including the retrieved SRB safing, repainting and refurbishment work stations, and new SRB processing and storage facilities during the first half of FY 1984. There are also modifications to improve the capability of the spacecraft assembly and encapsulation facility (SAEF-2) by December 1984, and to construct and activate a cargo hazardous servicing facility by October 1985. Procurement, installation, and checkout of equipment funded are under this budget element in FY 1984 to support the above described facilities funded from the Construction of Facilities appropriation. Larger second line station projects starting in FY 1983 and continuing through FY 1984 include the construction, outfitting, and activation of launch pad B and MLP-3, and the Centaur-related modifications of launch pads A and B to add a rolling-beam type liquid-hydrogen loading umbilical system on each launch pad. Another Centaur-related change is the addition of another liquid oxygen loading umbilical on each MLP. These new systems plus a set of current-design umbilicals and swing arms for pad B are to be tested and proofed at the launch equipment test facility.

Also under launch and mission support are the procurement and modification of a third Gulfstream II for use as a Shuttle training aircraft, the fabrication of the manned maneuvering units and extra-vehicular mobility units (space suits), and other mission support activities for training and simulations.

The Mission Control Center upgrading (Level 11) will provide for the reconfiguration of the MCC at JSC to support operational flight schedule requirements. The two-vehicle operations capability for supporting higher flight rates will be available in April 1984 with the completion of the flight control rooms on the second floor of the MCC. Modification work will continue in FY 1984 on the three-vehicle operations capability.

BASIS OF FY 1984 FUNDING REQUIREMENTS**PROPULSION SYSTEMS**

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Main engines.....	163,300	285,700	346,300	280,700
solid rocket motor.....	22,000	86,800	99,200	108,400
External tank.....	45,700	115,600	89,900	83,100
Systems support.....	---	13,900	17,900	---
Total.....	<u>231,000</u>	<u>502,000</u>	<u>553,300</u>	<u>472,200</u>

OBJECTIVES AND STATUS:

Propulsion systems provides for the production of the Space Shuttle's main engines and the development of the capability to support operational requirements established for the main engine, SRB, and ET. In the main engine program, production and capability development covers the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations, and anomaly resolution capability. In the SRB, the development of the filament wound case solid rocket motor and the redesign of the hardware to meet program requirements for reusability and operational cost reduction are being pursued, in addition to the procurement of manufacturing tooling and equipment to support fabrication, transportation, and checkout for meeting the higher flight rates. In the ET program, the objectives are to provide the manufacturing capability to meet the increase in production build rate requirements and to develop improved manufacturing techniques and management processes to reduce the time and cost of producing tanks. Systems support primarily provides for the testing of the main engines in the main propulsion test article configuration, in addition to systems engineering support.

The main engines performed superbly during the first five flights of the Space Shuttle, culminating many years of testing and continuing engineering analyses. The fact that these flights were completed with no significant in-flight anomalies and with only minimal between-flight maintenance validated the concept of the reusable high-performance rocket engine. The main engine program is currently focused on the flight

certification testing of the new full power level engines. This engine will produce 512,000 pounds of thrust in vacuum, i.e., 109 percent of the thrust produced by the engines used on Columbia for its first five flights. As of December 1982, this new configuration engine has completed more than 170 tests totalling over 45,000 seconds of test time, and has successfully completed three of the planned four flight certification cycles. Full certification is planned to be completed by February 1983. Production engine delivery schedules have been adjusted to compensate for the changeout of the Columbia's engines after the fifth flight and for the addition of an engine (2027) to the production sequence to replace engine 2013, destroyed during early full power level certification testing. Engine test incidents during FY 1982 also led to the need for additional hardware fabrication to support the on-going test program.

Although the SRBs performed well during the initial five flights, the damage incurred upon water impact--as well as the loss of the STS-4 boosters due to problems experienced with parachute deployment--has resulted in the need for design improvements to reduce the amount of damage, particularly to the aft skirt equipment. Interim fixes have been pursued, resulting in reduced SRB damage on STS-5. The loss of the SRB's on STS-4 has been traced to a premature separation of the main parachutes from the booster at frustum separation. Design improvements are being studied to reduce the damage experienced to the thrust vector control system. The aft skirt structures are being strengthened as well. The new high performance motor, scheduled for flight in 1983, successfully completed its developmental test firing in October 1982; the qualification motor test firing is scheduled for March 1983 and first flight use is planned on STS-8 in mid-1983.

The SRB program includes the development of a filament wound composite motor case. This development effort will enable the replacement of the current steel case segments for high performance launches. The performance increase is achieved by a reduction in the Shuttle liftoff weight of approximately 66,000 pounds as compared to the baseline steel case motors. This results in a payload capability improvement of approximately 5,500 pounds. The development contractor has been selected and work has been initiated. Structural development tests will be conducted in 1983 at the subscale, quarter scale, and full diameter configuration levels. The first flight use is planned for late 1985 on the initial Vandenberg launch.

In the ET program, significant progress has been made on the development of the new lightweight tank, including the changes to the manufacturing tools at the Michoud Assembly Facility involved in changing over from the heavyweight to the lightweight configuration. The first lightweight tank was delivered on schedule to the KSC in September 1982. A key element of the program has been to identify manufacturing flow "choke points" where existing tools require modification or new tools should be added to meet the production capability requirement of producing 24 tanks per year by 1987. Emphasis continues on efforts to reduce manufacturing costs and improve the production capability of the systems supporting the manufacturing operations.

In systems support, preparations are underway for the test of the full power level engines in the main propulsion test article stand at the NSTL in April 1983. This test will provide for a check of the main engines' performance in conjunction with the main propulsion system hardware mounted in the aft end of the simulated orbiter.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

Propulsion system requirements have increased by \$51.3 million from the FY 1983 budget request. Main engine requirements have grown by \$60.6 million, largely as a result of problems encountered during FPL development and certification tests. Over the past year, three engine incidents occurred as a result of the higher temperatures and pressures developed during FPL test operations. Modifications were made, as a result of these failures, in both hardware design and engine operation sequencing to reduce operating temperatures and avoid future losses. However, as result of these losses, it was necessary to add one additional engine, 2027, to the production schedule and sufficient long-lead hardware and critical components to replace the hardware lost in these incidents. In addition, the development of a new engine controller design, was initiated based on concerns over forecast parts obsolescence for existing controllers.

The funding for spares and ground testing of engines in the current estimate for the main engine also reflects a change in the approach to budgeting for these items. Previously, the budget estimates for Shuttle operations included flight "insurance" spares and an allocation of ground engine testing support for anomaly resolution. After review, a program decision was made to consolidate all ground testing costs in Shuttle production and capability development due to the lack of a firm basis for deciding how much, if any, ground testing would be required to resolve flight anomalies--when and if these anomalies occurred. Further, it was decided that flight operations costs should reflect only the main engine spares required to replace units which had reached the established limits on their flight operating times; formerly, these established mean times before replacement (MTBR) estimates had been multiplied by a factor of two to insure that sufficient spares were budgeted for operations. These insurance spares will be provided for in Shuttle production and capability development. The effect of these decisions was an increase of \$30 million in this budget element and a corresponding decrease in the current estimate for Shuttle operations (orbiter flight hardware).

The increase in funding required for the SRB is related to the requirement to repair and refurbish hardware damaged during the developmental flights, to redesign the thrust vector control system, and to rephase the test schedule for the high performance motor. Definitization of tooling funding requirements in FY 1983 resulted in a rephasing of certain activities into FY 1984.

The decrease in ET funding reflects reduced tooling requirements for the application of the super lightweight ablator insulation, a change in the procurement approach for the acquisition of selected manufacturing tools and equipment, and rephasing of the need dates for other tools. Preliminary discussions have been held with the Martin Marietta Company to determine the basis for corporate investment in tools and equipment. The current estimate assumes that such an investment will occur, although NASA is currently reviewing the cost effectiveness of this approach as well as other approaches, such as leasing or direct procurement.

The increase in systems support is attributable to the change in the main propulsion test article firing from a planned firing in 1982 to the current schedule of April 1983.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, funding for the main engine provides for those activities necessary to support the orbiter production, flight schedules, and ground testing. Production flows have been adjusted to compensate for the planned changeout of the Columbia engines after five flights (instead of nine) as well as the addition of an engine (2027) to the production sequence as previously addressed. Flight spares lay-in, anomaly resolution testing, and continued certification and development testing are also provided for within the main engine budget estimates.

In the **SRB**, efforts will continue on the improvements to the thrust vector control system and other program elements to minimize flight damage and improve turnaround times on reusable hardware. Procurement of manufacturing tools, transportation support equipment, and related items will continue in support of reaching a 24 per year flight rate objective. In the filament wound case development activity, funding in FY 1984 provides for completion of characterization tests of the specific composite selected for use; reusability/refurbishment studies; subscale and full scale burst tests; motor firings of the first and second full scale development articles; and, initial fabrication of the first flight article.

In the ET program, producibility and production readiness activities will continue to support cost reduction and manufacturing processes improvement objectives. The manufacturing tools and equipment to support the 24 per year production rate build-up will be the principal focus of the FY 1984 program. Major tools, including tools for welding, machining, X-ray and for the application of insulation, as well as handling fixtures and transportation equipment are being procured.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

CHANGES AND SYSTEMS UPGRADING

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Changes and systems upgrading	---	72 ,500	25,000	52 ,700

OBJECTIVES AND STATUS:

Management, technical flight experience, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, funds are allocated to the appropriate budget account.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The changes and systems upgrading funds identified in the FY 1983 budget have been reallocated as identified in the individual program element justifications of changes from the FY 1983 budget estimates. The amounts reallocated to Shuttle production and capability development are \$37.5 million. The residual amount of \$10 million was part of the Agency's overall response to the general reduction made by the Congress in the NASA FY 1983 appropriations request for research and development activities.

BASIS FOR FY 1984 ESTIMATE:

The funding requested for FY 1984 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, by facilitating improved mission-to-mission turnaround time, and by improving mission performance margins.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>UPPER STAGES</u>			
	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Development	49,200	32,000	115,000	80,900
Procurement and operations	<u>57,500</u>	<u>63,000</u>	<u>52,000</u>	<u>62,300</u>
Total.....	<u>106,700</u>	<u>95,000</u>	<u>167,000</u>	<u>143,200</u>

OBJECTIVES AND STATUS:

The STS upper stages are required to carry Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Inertial Upper Stage (IUS), the Centaur, and the Payload Assist Modules (also called Spinning Solid Upper Stages) represent the three classes of upper stages available for use with the STS.

The IUS is being developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The first IUS launch took place in October 1982 in conjunction with a Titan 34-D booster; this combination successfully delivered two DOD communication satellites to the desired orbit. Inertial Upper Stage launch operations are proceeding on schedule for the first IUS/STS launch in early 1983 carrying the TDRS-A spacecraft. Plans for development of a planetary version of the IUS have been terminated. The number of IUS vehicles being procured for launches of the Tracking and Data Relay Satellite System has also been reduced, consistent with the change of the TDRSS to a dedicated Government system.

NASA and DOD have entered into a joint development program for a wide-body derivative of the Centaur stage as used in the Atlas Centaur program. The common vehicle, designated Centaur-G, will accommodate a 40-foot long, approximately 10,000-pound payload in the orbiter vehicle bay, and be capable of placing it into geosynchronous orbit. A longer version of the Centaur-G, known as G Prime, is being developed for launch of the Galileo and ISPM spacecraft in mid 1986. Two Centaur-G Prime vehicles are currently under procurement for the Galileo and ISPM missions. The Air Force and NASA will equally share common design and development costs for the Centaur-G. The Air Force and NASA will separately budget for hardware production and

operations costs associated with each agency's missions. Both NASA and DOD plan additional procurement of vehicles at a later date to meet future requirements. NASA plans to start procurement in FY 1985 of a Centaur-G vehicle to support the 1988 launch of the Venus Radar Mapper (VRM) mission, assuming the Congress approves the VRM development as requested in the FY 1984 budget request for space science programs. The planned activities for Centaur in 1983 include the work required on the **RL-10** engine used in the Centaur stage, including selected advanced development activities to investigate low thrust operations and extendable nozzle exit cones.

The objective of the Payload Assist Module (PAM) program is to provide low cost transportation, of principally commercial spacecraft, from the Shuttle's low Earth orbit to geosynchronous transfer orbit. The Delta class PAM-D is capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class (PAM-A) will be capable of inserting 4,400-pound payloads into the same orbit. PAM's are being developed commercially, but NASA monitors the development and production to assure that the PAM is technically adequate and will be available when needed. Eight PAM-D's have been successfully launched atop the Delta expendable launch vehicle and two more were successfully flown on STS-5. The PAM-D II is being developed commercially and will be capable of injecting 3,500 pound payloads into geosynchronous transfer orbit for missions to be launched beginning in early to mid 1985.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$72.0 million in the estimate is the result of a major program change. The FY 1983 Congressional budget was based on using a modified version of the DOD two-stage IUS to launch the Galileo and the ISPM mission. As directed by the Congress in July 1982, this planetary IUS development and associated flight hardware have been terminated, and development and production of Centaur/STS for these missions have been initiated. Also, due to the reformation of the Tracking and Data Relay Satellite System contract, it is possible to reduce the IUS procurement for TDRSS from six to four vehicles. Consistent with this program decision, \$17.0 million of funding previously planned for IUS procurement has been deferred and reallocated to Shuttle operations. The FY 1983 and FY 1984 estimates reflect the decision to develop and procure the Centaur/STS upper stages and to procure the four IUS vehicles.

BASIS FOR FY 1984 ESTIMATE:

Funds are required to complete the procurement of **NASA's** four IUS vehicles and to support the checkout and launch of the third Tracking and Data Relay Satellite (TDRS-C).

The FY 1984 funds are required to continue the development of Centaur-G and GPrime and the procurement of two Centaur G-Prime vehicles to support the Galileo and ISPM launches in 1986. The development effort in FY 1984 provides for the NASA share of the funding for the development of the common Centaur-G vehicle and the NASA costs for the additional development of the Centaur G-Prime. This includes the preliminary design review for all GPrime subsystems, the Critical Design Review for the GPrime Centaur integrated support structure and adapter, and the Critical Design Review for the test tanks and adapters for the G-Prime test vehicle. The procurement and operations resources are required to obtain long-lead materials for the G-Prime vehicles for the Galileo and ISPM missions, to conduct the Preliminary Design Review for the flight vehicles, and to initiate manufacturing of the GPrime flight hardware. Also, procurement of the PAM-A upper stage will be continued.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>SPACELAB</u>			
	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Development.....	100,800	113,200	115,800	100,200
Operations	<u>---</u>	<u>---</u>	<u>5,400</u>	<u>19,400</u>
Total.....	<u>100,800</u>	<u>113,200</u>	<u>121,200</u>	<u>119,600</u>

OBJECTIVES AND STATUS:

The Spacelab is a versatile, reusable facility carried in the cargo bay of the Space Shuttle orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. Ten European nations, including nine members of the European Space Agency (ESA), are participating in this joint development program with NASA. ESA has designed, developed, produced, and delivered the first Spacelab consisting of a pressurized module and unpressurized pallet segments, command and data management, environmental control, power distribution systems and much of the ground support equipment and software for both flight and ground operations. The Instrument Pointing System is scheduled to be delivered in FY 1984.

NASA is responsible for the remaining hardware including such major elements as the crew transfer tunnel, verification flight instrumentation, certain ground support equipment, and a training simulator. Support software and procedures development, testing, and training activities not provided by ESA which are required to demonstrate the operational capability of Spacelab are also included in NASA's funding. NASA is procuring an additional Spacelab unit from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement.

Spacelab operations provide for mission planning and flight and ground operations for all missions other than the development flights (SL-1 and SL-2). This includes integration of the flight hardware and software, payload operations data management, and logistical support.

During FY 1982, ESA Spacelab engineering model pallets were used to carry the science and applications experiments conducted on STS-2 and STS-3. The second flight configuration model of the Spacelab, which will

be flown on **SL-2**, and the second set of ground support equipment were delivered by ESA to NASA in FY **1982**. With the exception of the Instrument Pointing System, these are the last major elements of the ESA Spacelab development to be delivered to the United States. With these deliveries, there has been an increase in Spacelab activities at the KSC, involving the receipt, assembly, installation, checkout, and processing of the Spacelab hardware.

In December **1982**, the first crew transfer tunnel was delivered to KSC. This tunnel will link the Spacelab module to the Shuttle orbiter cabin for the first Spacelab flight (**SL-1**). Fabrication of the verification flight instrumentation for the **SL-1** mission has now been completed. The utility kits, which serve as Spacelab-to-Shuttle orbiter mating hardware, have also been delivered. Integration of the software for the Spacelab simulator, which will be first used in training for **SL-1**, was completed early in FY **1983**. Ground support equipment and facility verification testing was completed and Spacelab launch processing is well underway. KSC is engaged in integrating the experiments into the Spacelab flight module and onto the pallet that is scheduled to be flown in the cargo bay of the Shuttle in September **1983**. This work is being performed by the Spacelab integration contractor for NASA.

Four pallets and six racks were delivered to NASA early in FY **1983**. These deliveries are from the follow-on procurement contract which NASA signed with ESA in FY **1980** to purchase the second Spacelab. This contract represents a major portion of the FY **1983** and FY **1984** funding for Spacelab development. The hardware fabrication is well along and major deliveries will take place in FY **1984**.

CHANGES FROM 1983 BUDGET ESTIMATE:

The FY **1983** current estimate reflects an increase of **\$8.0** million over the budget estimate. This is due to the acceleration of the second tunnel delivery date, increased development requirements, and increased estimates for spares and maintenance costs. The requirement for operations funding in FY **1983** is based on the reallocation of Spacelab mission preparation manpower to meet the schedule for supporting the first operational mission (**SL-3**).

BASIS FOR FY 1984 ESTIMATE:

The first Spacelab verification flight (**SL-1**) is currently scheduled for the end of FY **1983**. FY **1984** funding is required to check out the Spacelab system components after flight and conduct post-flight data analysis for that mission. The second verification flight (**SL-2**), scheduled for FY **1985**, will require funding for analytical and physical integration, for checkout of the Spacelab elements, and to support training, including the operation of the Spacelab simulator. Development of the NASA-furnished ground support equipment required for **SL-2** is planned to be completed in FY **1984**.

Modification of ESA flight hardware and procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue in FY 1984. Funds are also required for expansion of the Software Development Facility's capabilities to support the planned flight rate. Production of the second Spacelab flight unit, which is under contract with ESA, will continue with major components scheduled to be delivered in FY 1984. Funding is also required for the initial lay-in of spares for the ESA-delivered hardware and to provide the sustaining engineering for all hardware and software beyond that for which ESA is committed.

FY 1984 operations funding is required for processing OSTA-3, SL-3, and the special structure missions (LFC-1, MEA-1, OAST-1 and OSTA-4). Staging and integration activities for OSTA-3 will lead to a launch planned for the last quarter of FY 1984. Integration and checkout of the Spacelab elements for the SL-3 mission are scheduled to be completed and ready for launch in the last half of FY 1984. Analytical integration, configuration management, and software development are additional activities to be conducted in FY 1984.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**ENGINEERING AND TECHNICAL BASE (DEVELOPMENT, TEST AND MISSION SUPPORT)**

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1983 <u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Research and test support	36,300	34,900	29,600	40,100
Data systems and flight support	40,700	12,700	9,200	13,100
Operations support	51,000	32,000	28,700	37,000
Launch systems support	<u>55,100</u>	<u>2,800</u>	<u>2,800</u>	<u>2,900</u>
Total	<u>183,100</u>	<u>82,400</u>	<u>70,300</u>	<u>93,100</u>

OBJECTIVES AND STATUS:

Through FY 1982, certain specific STS program support functions at the NASA field centers were funded in the Development, Test and Mission Support (DTMS) program element. The Engineering and Technical Base (ETB) represents a change in the approach to funding these functions. The ETB will provide only the core capability required to sustain an engineering and development base for various STS programs. Additional center program support requirements above the core level are consequently funded within Shuttle operations and Shuttle production and capability development. The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories, White Sands Test Facility, and reliability and quality assurance areas. The core level for the Central Computer Complex is established as a two-shift operation. The funding for center operations base support is split between the ETB and Shuttle operations budget elements in accordance with the principle that ETB will provide the core level and the benefitting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides only for the analysis of improvements to KSC operations. The shift to the ETB concept did not result in significant changes to the funding for MSFC and NSTL operations. These centers will continue

under ETB to use these funds at MSFC for multi-program support activities, including computational and communications services, and at NSTL for facilities operations, including security.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The current estimate for new obligational authority for ETB in FY 1983 has been reduced by \$12.1 million. This reduction is largely the result of several actions taken in FY 1982 which made more obligational authority available to carry over and apply against FY 1983 requirements. The actions taken involved reducing manpower and procurements of supplies and materials, and continuing to lease the JSC computers in the Central Computer Complex, based on studies which showed that the mode was more cost effective than purchasing the computers.

BASIS FOR FY 1984 ESTIMATE:

The requested funding for the ETB in FY 1984 provides for a continuation of the FY 1983 level of support for institutional research and development facilities and services at the centers. The increase in FY 1984 budget authority requirements over FY 1983 reflects the effects of inflation on wages and other costs and the absence of an unobligated funding carryover similar to that which reduced the FY 1983 new obligational authority requirements, as addressed above.

In research and test support, the JSC will provide a five-day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Shuttle Avionics Integration Laboratory, the Electronic Systems Test Laboratory, and the Water Immersion Facility. Present supporting activities at MSFC will be continued during FY 1984.

Data systems and flight support will provide a minimal core level of support based on a five-day, two-shift operation of the central computer facility at JSC.

Operations support funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in 1984 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house hardware; (4) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for support and surveillance of tests; (5) photographic services, including still and motion picture processing, and audio-visual mission support;

(6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (9) management services in support of center operations, including data management, microfilming, and preparation of technical documentation. In addition, 1984 funds will provide the basic level of institutional support at NSTL for continuing Space Shuttle main engine testing activities.

In launch systems support, funds are required to continue investigations of the research and development technologies available to enhance launch site hardware, ground processing, and support systems.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Payload operations.....	24,900	34,500	20,300	30,600
Payload support equipment.....	<u>21,400</u>	<u>26,900</u>	<u>24,100</u>	<u>22,600</u>
Total.....	<u>46,300</u>	<u>61,400</u>	<u>44,400</u>	<u>53,200</u>

OBJECTIVES AND STATUS:

The payload operations and support equipment program objective is to centralize the provision of payload services, both unique and common, which are required beyond the basic standard Shuttle services. Payload operations provides unique hardware, analysis, and launch site services to support STS missions--including mission management of the Solar Maximum Mission retrieval/repair activities. Payload support equipment funds the development and acquisition of reusable ground support equipment required for a wide range of payloads including Spacelab. In addition, this program provides for the activation and operations of the Payload Operations Control Center (POCC) located at JSC; this facility enables command and control of Shuttle/Spacelab attached payloads.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The funding for payload operations has been revised in consideration of reevaluated payload support requirements and launch date schedule changes. Significant changes for planetary payloads have been incorporated due to the changes in the upper stages to be used for the Galileo and the ISPM. These rephased requirements include spacecraft to upper stage integration and funding for the provisions of the orbiter--unique integration hardware and analysis. In addition, the technical requirements for RTG cooling for planetary payloads have been reduced due to relief of critical ISPM orbiter temperature tolerances, and the change in the launch schedule has allowed deferral of work consistent with the revised launch dates. Funding provisions for unanticipated payload requirements have been eliminated to reflect updated estimates

for the ongoing payload integration process. FY 1983 funding previously carried in Shuttle production and Shuttle operations has been included in this budget element to consolidate the funding required to support the Solar Maximum Retrieval/Repair Mission. In addition, as directed by the Congress, the **NASA** funding for the recurring costs of this mission has been reduced by applying funds received from the WD.

Payload support equipment estimates for FY 1983 reflect deferrals of cargo integration and test equipment consistent with the delayed launch dates of payloads supported by the Centaur upper stage, and changes to the payload bay bridge development schedule.

BASIS OF FY 1984 BUDGET ESTIMATE:

Payload operations funding in FY 1984 is required to furnish continued payload services for currently scheduled **NASA** launches. Payloads receiving support during this year include the mission to retrieve and repair the Solar Maximum Mission spacecraft, Galileo, ISPM, TDRS, Space Telescope, SL-2 and SL-3.

FY 1984 funding for payload support equipment will be used for the development, test, and installation of mixed cargo and test equipment, on-site cargo transporter, and long lead initial spares. FY 1984 funding also provides for the operations and maintenance of the POCC which supports the early Spacelab missions.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>ADVANCED PROGRAMS</u>			
	<u>1982 Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>Budget Estimate</u>
Advanced programs.....	9,700	11,900	11-900	15,000

OBJECTIVES AND STATUS:

The principal objective of advanced programs is to provide technical and programmatic data for the definition and evaluation of candidate future Office of Space Flight programs. Advanced programs activities have been the source of information for major new programs and systems including Apollo, Skylab, and Shuttle. Subsystem studies and supporting development activities are conducted to demonstrate the required performance and reliability improvements in order to reduce future program cost, schedule, and performance risks.

In FY 1983, the advanced programs effort will be focused on conducting system and subsystem studies and advanced development for the continued definition of free-flying and tethered space platforms to operate with the Shuttle as well as for potential use with a space station; the investigation of advanced systems, tools, and techniques for placement, retrieval, and maintenance/repair of spacecraft; the definition of advanced transportation vehicle concepts, including orbital transfer vehicles and Shuttle-derived launch vehicles; and the initial mission analyses and trade studies related to a space station.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, major emphasis will be placed on preliminary concept studies with funding of some key advanced development items. The major goal continues to be the definition of the systems architecture and system elements needed for potential space operations over the next twenty years. System options fall into three categories: platforms and facilities in both low-Earth orbit and geosynchronous orbit; orbital services such as satellite servicing; and advanced transportation. In the platforms program area, system concept studies and design trade-offs will be concentrated on platforms operating from and supported by a space station, and flexible carriers for payloads of opportunity for use with the Space Shuttle. Orbital services

will focus on the uses of the Shuttle for satellite servicing near and remote from the Shuttle for large structures assembly and support; man-operated equipment, tools and techniques for satellite servicing near and remote from the Shuttle or a space station; and use of the orbiter to demonstrate refueling, servicing, and checkout of spacecraft on-orbit. The advanced transportation effort will define a reusable evolutionary upper stage concept to be based on the Shuttle and space station, as well as equipment studies of certain Shuttle derived Earth-to-orbit launch vehicle systems. Manned system tests and engineering evaluations of laboratory models of regenerative life support systems developed through FY 1983 will be performed. Prototype development, simulation, and tests will be implemented to investigate the utility and efficiency of new manned extra-vehicular and teleoperated systems. As part of construction operations, studies of assembly and repair of future satellites in space will be undertaken, as well as studies of extra-vehicular activity operations essential for platform maintenance.

In the space station studies area, a low-level effort will continue to explore requirements and operational concepts. This effort will take advantage of the results of activities continued from FY 1983 such as the mission analyses and architectural trade studies.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

TETHERED SATELLITE SYSTEM

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Tethered satellite system.....	---	---	---	3,300

TI AND STATUS:

The Tethered Satellite System (TSS) will provide a new capability for conducting space experiments in regions remote from the Space Shuttle orbiter. By means of a closed-loop control system acting upon a tether, payloads of 200 to 500 kg can be deployed to distances of 100 km and held in a fixed position with respect to the orbiter. A number of significant scientific objectives can be uniquely undertaken with a TSS facility, such as: the observation of important atmospheric processes occurring within the lower thermosphere; new observations of crustal geomagnetic phenomena; the direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125-150 km altitude region; and entirely new electrodynamic experiments and in situ observations in previously inaccessible regions. The TSS will be an international cooperative program with the Italian government. The United States will develop the deployment mechanism and will be responsible for overall program management and integration with the orbiter. Italy will develop the satellite and will also be responsible for instrument and experiment integration. The planning estimate for the total development cost for the United States activities is estimated at \$40-50 million. The TSS is scheduled to be available for launch in 1987.

BASIS FOR FY 1984 ESTIMATE:

The funding in FY 1984 will provide for the initiation of hardware development following advanced development activities conducted in FY 1983. It is our understanding that the Italian government has authorized all funds necessary to complete the development and flight of the satellite.

SPACE
TRANSPORTATION
OPERATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE

ON OPERATI

PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1983 <u>Current</u> <u>Estimate</u>	1984 <u>Budget</u> <u>Estimate</u>	Page <u>Number</u>
<u>Space Transportation Operations</u>					
<u>Shuttle Operations</u>	435,300	1,316,600	1,370,700	1,520,600	
Flight operations	71,300	314,200	330,100	315,000	RD 2-5
Flight hardware	357,600	659,200	692,100	848,400	RD 2-8
Launch and landing operations	6,400	343,200	348,500	357,200	RD 2-10
<u>Expendable Launch Vehicles</u>	31,200	42,800	83,000	50,000	RD 2-12
<u>Delta</u>	30,400	42,800	83,000	50,000	
<u>Sat</u>	800	---	---	---	
<u>Total</u>	466,500	1,359,400	1,453,700	1,570,600	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center.....	73,333	368,000	370,700	388,400
Kennedy Space Center.....	8,554	343,100	347,200	354,900
Marshall Space Flight Center.....	347,274	582,500	629,900	755,000
Goddard Space Flight Center.. ..	27,600	41,200	81,400	49,400
Jet Propulsion Laboratory	49	---	---	---
Ames Research Center.....	---	1,400	3,000	3,200
Langley Research Center.....	800	---	---	---
Headquarters.... ..	8,890	23,200	21,500	19,700
Total.....	<u>466,500</u>	<u>1,359,400</u>	<u>1,453,700</u>	<u>1,570,600</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE FLIGHT

SPACE TRANSPORTATION

U.S. SPACE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Space Transportation Operations provides the standard operational support services for both of the primary U.S. space launch systems: the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and the manpower, propellants, and other materials are furnished to conduct and support both flight and ground (launch and landing) operations. The Space Shuttle operations program provides for the launch of NASA, Department of Defense (DOD), other U.S. Government, domestic commercial and international missions. Five flights are planned for launch in FY 1983. Eight to nine missions are planned in FY 1984, depending upon reflight requirements and identification of new mission requirements. The Vandenberg launch site is planned to be activated on a schedule which would enable a first flight to take place as early as late 1985.

The Space Shuttle provides launch services to non-NASA users on a reimbursable basis; the amount paid by such users is tied to the size of the user's payload and the services required to support his launch requirements. For flights through FY 1985, the computation is based on a full mission cost for standard launch services of \$18.0 million per flight in 1975 dollars; for FY 1986-1988 flights, the charge will increase to \$38.0 million in 1975 dollars, or approximately \$71 million in FY 1982 dollars. The budget is based on charging DOD \$16.0 million in 1975 dollars for dedicated flights in FY 1984 and FY 1985, and \$29.8 million in 1975 dollars for flights during FY 1986-1988. The Bureau of Labor Statistics computation of compensation per hour is used as the index for escalating 1975 dollars to current dollars for billing purposes. The projected receipts from reimbursable users are applied against total program funding requirements to derive the amount of appropriated funds requested.

The Shuttle operations budget requests fund three principal areas: flight operations, flight hardware, and launch and landing operations. Under flight operations is the training, mission control, and flight operations planning, payload integration analysis, mission analysis, and post-flight anomaly resolution; flight hardware includes the external tanks (ET), solid rocket boosters (SRB), main engine flight Spares, orbiter spares (including overhaul, repair and logistics), and Marshall Space Flight Center (MSFC) systems support; and launch and landing operations covers Kennedy Space Center (KSC) operations, contingency landing site provisions, and Dryden Flight Research Facility (DFRF) operations.

The objective of the expendable launch vehicles program is to provide for the centralized procurement of launch vehicles and the launch support services for NASA's automated spacecraft missions, as well as for other agencies and organizations utilizing these systems and services on a reimbursable basis.

The expendable launch vehicle transportation systems consist of the Scout, the Atlas Centaur, the Delta, and the Atlas-F vehicles. This family of launch vehicles has been developed to support NASA's automated spacecraft launch requirements and, on both a cooperative and a reimbursable basis, to support other government, international, and commercial agencies and organizations. The expendable launch vehicle program includes the procurement of vehicle hardware, launch services, engineering, and maintenance support, including the necessary reliability improvements of the launch vehicle, and the ancillary ground equipment. In FY 1984, only the Delta requires appropriated funding; the Scout, Atlas-Centaur, and Atlas-F are on a fully reimbursable basis.

Expendable launch vehicles are launched from sites located at the Eastern Space and Missile Center (ESMC) in Florida, the Western Space and Missile Center (WSMC) in California, the Wallops Flight Facility in Virginia, and the San Marco Platform off the African coast near Kenya.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	1982 <u>Actual</u>	<u>FLIGHT OPERATIONS</u> 1983		1984 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of	<u>Current Estimate</u> Dollars)	
Mission support... ..	27,700	121,300	107,000	118,200
Integration	34,500	150,600	147,300	155,800
Support.. ..	<u>9,100</u>	<u>42,300</u>	<u>75,800</u>	<u>41,000</u>
Total.....	<u>71,300</u>	<u>314,200</u>	<u>330,100</u>	<u>315,000</u>

OBJECTIVES AND STATUS:

Shuttle operations funding is combined with the reimbursements received from other U.S. Government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. Significant missions included in the early operations time frame are the first commercial satellites deployment in November 1982, the launch of the TDRS-A in early 1983, the first Spacelab flight in the fall of 1983, and the first dedicated launch of a DOD payload in late 1983.

Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include preparation of development system and software handbooks, flight rules, detailed crew activity plans and procedures, development of Mission Control Center and network systems requirements, and operations input to the planning for the selection and operation of Shuttle payloads.

Specific flight planning activity encompasses the flight design, flight analysis, and software activities. The flight design tasks include supporting the crew training simulations and development of flight techniques. Flight design products include conceptual flight profiles and operational flight profiles which are issued for each flight. The software activities include the development, formulation, and verification support for the guidance, targeting, and navigation systems software requirements in the orbiter and Mission Control Center (MCC). In addition, the flight-dependent data located in the erasable

memory (mission-to-mission changes) is developed from the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems.

Integration includes: the identification of operational requirements for the design of planned and improved spacecraft systems; the development of flight techniques for utilization of these systems; and conceptual level profile development and analysis, beginning about two years before the flight; and operational profile development and analysis, accomplished in the period immediately prior to the flight. Analytical integration is performed for payloads in the cargo bay and mid-deck and for Getaway Special cannisters, as are the engineering, testing and quality assurance necessary for system operations.

Support for flight operations ranges from the Johnson Space Center (JSC) base operations support to system activities at Headquarters and the Goddard Space Flight Center (GSFC), to the effort associated with the system-wide improvements necessary to achieve the planned flight rate and schedule reliability required for mature system operations.

The Space Transportation System (STS) flight rate will nearly double in FY 1983 from the year before (from three in FY 1982 to five in FY 1983), and will nearly double again (to 8-9) in FY 1984. The program is transitioning from a developmental stage of operations into a mature operational phase. There are new capabilities being added to the program (new orbiters, different types of payloads, different upper stages, lightweight external tanks, and higher performance solid rocket boosters) which make this a complex transition. The program is developing the reconfiguration tools in the software, mission planning and integration area so that the orbiters, the simulators and the MCC will be capable of carrying out training and operations involving the several additional capabilities planned for introduction in this period.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$15.9 million from the budget estimate reflects: the new requirement for communications support at Dakar, Senegal, for the Trans-Atlantic Landing abort capability; provisions for night landing capability at the primary, secondary, and several contingency landing sites; the reallocation--as a result of the reduction in Inertial Upper Stages procurement--of \$17.0 million previously included under the budget element for upper stages. This \$17.0 million, together with \$17.5 million budgeted under Shuttle operations, represents the \$34.5 million of FY 1983 funds designated for deferral for obligation until FY 1984, consistent with the changes in the launch plan for the Tracking and Data Relay Satellite System; reduced funding requirements for orbiter engineering support; and reallocation to payload operations and support equipment of the recurring costs for the retrieval and repair of the Solar Maximum Mission.

BASIS FOR FY 1984 ESTIMATE:

The flight operations portion of the Shuttle operations budget sustains the maintenance and operation of the onboard avionics software and the mission control systems; maintenance and operations of the training and flight proficiency aircraft and simulators for crew training; and analysis and generation of the mission planning necessary to conduct and control the mission and instruct the flight crew. Flight operations also includes the sustaining engineering required to integrate all flight elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; support of crew operations and training programs; and program support at JSC and NASA Headquarters. In addition, orbiter sustaining engineering manpower is required in support of the orbiter vehicle to insure maintainability, reliability, and anomaly resolution during operations; also, the amount required over the core engineering and technical base for the operations and maintenance of the Shuttle Avionics Integration Laboratory (SAIL) is provided to test and verify the ongoing operations software and hardware modifications. These configuration changes result from mission-unique requirements or system changes/redesigns intended to reduce costs. The SAIL is a key element in the capability of the system to investigate and resolve anomalies experienced on the ground or in flight. Also included is update and verification of flight software, post-flight assessment, and ground turnaround evaluation.

Further, flight operations includes the Getaway Special support managed by GSFC for the payload integration activities at KSC, the flight crew mission requirements and timeliness, and the safety certification at JSC. Also, included are the operations and maintenance support, printing, equipment rentals and supplies, and materials for the base operations activities at JSC.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**FLIGHT HARDWARE**

	<u>1982</u>	<u>1983</u>	<u>1984</u>
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Budget</u> <u>Estimate</u>
		Dollars)	
Orbiter.....	25,200	141,500	159,000
Solid rocket booster.....	156,200	244,200	353,200
External tank.....	176,200	273,500	336,200
Total.....	<u>357,600</u>	<u>659,200</u>	<u>848,400</u>

OBJECTIVES AND STATUS:

The flight hardware program element provides for the procurement of external tanks (ET); solid rocket motors, booster hardware, and propellants; spare components for the main engines; orbiter spares; sustaining engineering and logistics support for external tank/solid rocket booster/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Included in the funding request for external tanks, solid rocket motors and boosters are the long-lead time raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a consistent manner with the increasing flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain as smooth and efficient a buildup of the production capability as possible. The procurement of some elements of the solid rocket booster (SRB) has, however, been accelerated to reflect the need for additional hardware to protect against the hardware attrition and refurbishment problems encountered during the orbital flight tests. In the ET, an efficient and nondisruptive production process is being developed which enables manufacturing, assembly, and checkout operations to proceed on a basis which allows for timely delivery of flight hardware to the launch site. The orbiter line element includes: main engine overhauls, procurement of replacement spare parts and attendant sustaining engineering; provision for the fixed level of annual support for the liquid hydrogen plant; orbiter spares for replenishment of line and shop replaceable units, and the manpower for supporting this logistics operation; and, replacement spares, field support, and maintenance of crew-related equipment. Some examples of orbiter spare equipment are fuel cells, tiles for thermal protection, tape recorders, leading edge

support structures, wheels, brakes and pyrotechnics. The crew-related equipment activities include support to the pre-flight training and flight usage of the extra-vehicular maneuvering unit (EMU), emergency portable oxygen systems, radiation instrumentation, survival radios, closed-circuit television cameras, and food and other galley-related items.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The current estimate exceeds the budget estimate by \$32.9 million. The decrease in the orbiter estimate is due principally to the decision to reduce the main engine spare components only to the amount estimated for flight replacement requirements, and to consolidate provisions for ground testing in support of anomaly resolution within Shuttle production and capability development.

The increase in the SRB estimate is attributable to the need for reusable hardware acceleration to offset longer turnaround times for hardware damaged on water impact and to meet need dates at the launch site. External tank requirements have increased to provide for the continuation of the additional thermal insulation to protect against ice formation, and for added hardware delivery margins to assure meeting early FY 1984 delivery dates.

BASIS FOR FY 1984 ESTIMATE:

Orbiter flight spares and crew equipment spares are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure spares. Main engine hardware provides for manufacturing and delivery of engine component spares. Flight hardware production deliveries for the SRB and ET are based on lead times required to support the FY 1984 flight rate and also the necessary costing of materials and component hardware to start refurbishment and fabrication activities for flights in future years. Ten sets of SRB hardware and eleven ETs are scheduled for delivery to KSC in FY 1984.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

LAUNCH AND LANDING OPERATIONS

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1984</u> <u>Budget</u> <u>Estimate</u>
Launch operations	---	297 ,000	302,500	301,600
Payload and launch support.....	<u>6,400</u>	<u>46 ,200</u>	<u>46 ,000</u>	<u>55 ,600</u>
Total.....	<u>6,400</u>	<u>343 ,200</u>	<u>348,500</u>	<u>357 ,200</u>

OBJECTIVES AND STATUS:

Launch and landing operations provides for the launch preparations and the launch and landing operations of the Space Shuttle. The orbiter, ET, SRBs, main engines, and payloads are checked out, integrated, and launched from KSC at Cape Canaveral, Florida. The SRBs are retrieved from the Atlantic Ocean after separation from the Shuttle. Space Shuttle landing support is furnished at KSC, DFRF, and contingency landing sites. The major facilities used for launch and landing operations include: the orbiter processing facility, the vehicle assembly building, mobile launcher platforms, SRB processing and storage facility, payload processing facilities, launch pads, and the Shuttle landing facility.

Funding for launch and landing operations supports the manpower, ground support equipment, and propellants required to accomplish the integration and processing of the Shuttle and its payloads. Under launch operations, manpower is provided to process and integrate the orbiter, ET, solid rocket motors/boosters and the main engine into the proper launch configuration preparatory to each flight. Support manpower is also included to conduct the SRB retrieval operations, configuration control, transportation, inventory control and program support including operations and maintenance of the facilities and equipment. Funding for payload and launch support provides for the processing and integration of the payloads, procurement of spares for ground support equipment, propellants for launch operations and base support (excluding SRB propellants), and landing support at the DFFU?

The Shuttle's first operational flight (STS-5) occurred in November 1982. Turnaround times for the Shuttle hardware have rapidly decreased through the orbital flight tests (STS-1 through STS-4) and the

initial operational flight, indicating that the system is capable of progressing over the next several years into a mature operational system able to handle the increasing flight rate. The multiple contractors used during the developmental phase to carry out Shuttle processing and base operations are being phased into two major contracts: a Shuttle processing contract (SPC) and a base operations contract (BOC). Consolidation of these contracts is viewed as a necessary means of reducing the manpower required for launch and landing operations and minimizing the degree of government involvement, thereby reducing the effective cost per flight. A single base operations contract was awarded in December 1982, and a request for proposals will be issued in early 1983 for a single Shuttle processing contract.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$5.3 million reflects the added requirement for a flight readiness firing (conducted in December 1982) for the second flight orbiter, Challenger; increased manpower needs for vehicle and ground operations to support the five launches planned for FY 1983; decreased allowance for initial start-up costs for the base operations contract and Shuttle processing contract due to later-than-planned initiation of these contracts; and, minor adjustments due to the consolidation of program support manpower allocations to other projects (such as Spacelab) within launch and landing operations.

BASIS FOR FY 1984 ESTIMATE:

Launch and landing operations funding in FY 1984 provides for the manpower necessary to accomplish vehicle and payload processing to support the 8-9 launches planned for FY 1984. This includes manpower for the various Shuttle flight elements, support for the launch processing system (LPS) automatic checkout and launch operations capability, and sustaining engineering. Implementation of the Shuttle processing contract is scheduled for late 1983; the initial start-up costs and projected manpower savings are reflected in the estimate.

Payload and launch support will provide for the procurement of the spares for ground support equipment (such as hydraulic system valves, cryogen system pumps, replacement mobile launcher platform crawler shoes, and LPS magnetic tapes), propellants for launch operations and base support, contractor support for the maintenance of the cargo interface test equipment (CITE), payload integration manpower, and landing support requirements for landings at DFRF.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

	<u>EXPENDABLE LAUNCH VEHICLES</u>			
	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Delta.....	<u>30,400</u>	<u>42,800</u>	<u>83,000</u>	<u>50,000</u>

OBJECTIVES AND STATUS:

The Delta launch vehicle is the ~~most~~ widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 165 launches and has experienced a success record of over 92 percent. It is presently operational with two- and three-stage configurations. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation. The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) or, in the 3920 configuration, a 1,270 kilogram (2,800 pounds) payload into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet).

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase in FY 1983 funding requirements reflects the **loss** in reimbursable income anticipated from Delta customers who now plan to launch their missions on Shuttle or Ariane. Increased NASA funding is accordingly required to enable the hardware production contracts to be continued, although NASA is taking action to reduce the number of Delta vehicles procured. The vehicles being procured are necessary to meet launch requirements of NASA, the National Oceanic and Atmospheric Administration of the Department of Commerce, and firm non-governmental users.

BASIS OF FY 1984 BUDGET ESTIMATE:

The FY 1984 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support Landsat-D' and AMPTE NASA spacecraft requirements. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

This vehicle system, planned to be operational at least until 1986, is the ~~most~~ utilized of our current vehicles. It is being used to support user requirements, on a reimbursable basis, ~~for~~ launching missions for other U.S. Government, commercial, and international customers.

SPACE SCIENCE AND
APPLICATIONS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR SPACE SCIENCE AND APPLICATIONS PROGRAMS

<u>Programs</u>	Budget Plan			
	1982 <u>Actual</u>	1983 Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	1984 Budget <u>Estimate</u>
Physics and astronomy....	322,433	436,400	441,000	514,600
Life sciences.....	39,500	55,700	55,700	59,000
Planetary exploration.....	210,000	175,600	186,400	205,400
Solid earth observations.....	149,400	132,200	132,200	74,400
Environmental observations.....	133,023	156,500	156,900	163,000
Materials processing in space.....	16,244	22,000	22,000	21,600
Communications.....	21,300	12,400	32,400	21,100
Information Systems.....	<u>4,300</u>	<u>7,500</u>	<u>7,500</u>	<u>8,900</u>
<u>Total.....</u>	<u>896,200</u>	<u>998,300</u>	<u>1,034,100</u>	<u>1,068,000</u>

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

	SPACE SCIENCE	Physics & Astronomy	ISPM	Shuttle Payload Dev. & Mgmt.	MO&DA	Explorer Operations	Other MO&DA	Research & Analysis	Support Research & Technology	Advanced Tech Development	Data Analysis	Suborbital	Sounding Rockets	Other Suborbital	Other Physics & Astronomy	Planetary	Life Sciences	From Applications to Space Science	To Applications from Space Science
<u>Old Structure</u>	<u>682.0</u>	<u>471.7</u>	21.0	81.4	85.6	(28.3)	(57.3)	39.2	(25.2)	(6.1)	(7.9)	38.2	(28.8)	(9.4)	206.3	<u>154.6</u>	<u>55.7</u>		
<u>New Structure</u>																			
Physics & Astronomy	<u>436.4</u>	<u>423.1</u>																13.3	
Shuttle S/L P/L	<u>83.0</u>			81.4														<u>1.6</u>	
MO&DA	73.2					15.9	57.3												
Research & Analysis	26.8								17.4	2.6	6.8								
Suborbital	47.1												26.0	9.4				11.7	
Other P&A	206.3														206.3				
Life Sciences	<u>55.7</u>																<u>55.7</u>		
Planetary	<u>175.6</u>	<u>21.0</u>														<u>154.6</u>			
ISPM	21.0		21.0																
Other Planetary	154.6															154.6			
To Environmental Observations	<u>27.6</u>					12.4			7.8	3.5	1.1		2.8						27.6

1/Materials Processing S/L P/L development transferred to Physics & Astronomy S/L P/L

2/Application System (AIRP) efforts continued under Suborbital Program

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

Old Structure	APPLICATIONS	Resources Observations	Spacelab Payload Development	AR&DA	Multi-Linear Array	Other AR&DA	Other Resources Observations	Environmental Observations	Upper Atmospheric Research Program	AR&DA	Extended Mission Operations	Other Environmental Observations	Applications System	Materials Processing	Spacelab Payload Development	Other Materials Processing	Communications & Information Systems	From Space Science to Applications	To Space Science from Applications
<u>New Structure</u>																			
Solid Earth Observations	132.2	132.2																	
S/L P/L Dev.	13.8		2.8		11.0														
AR&DA	13.7					13.7													
Other Solid Earth Observations	104.7						104.2												
Environmental Obs.	156.5							128.9										27.6	
Research & Analysis	86.4								16.5	54.7								15.2 ^{1/}	
MO&DA	22.4										10.0							12.4 ^{2/}	
Other Environmental Observations	47.7											47.7							
Materials Processing	22.0													22.0					
Space Proc. R&A	13.1														1.7	13.1			
Material Exper. Ops.	8.9															7.2			
Communications & Info. Sys.	19.9																19.9		
To Physics & Astronomy													11.7	1.6	(1.6)				13.3

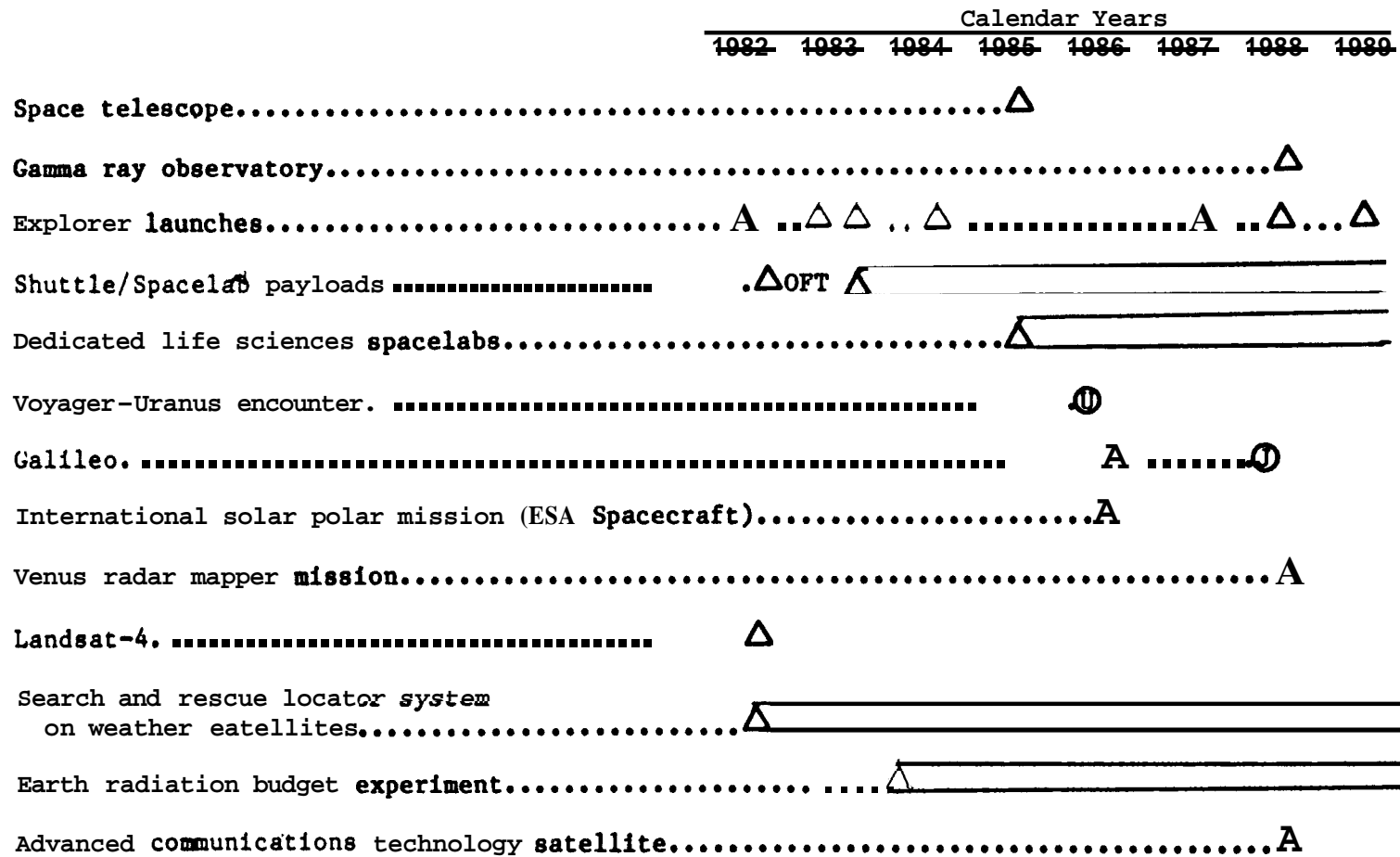
^{1/}Physics & Astronomy R&A (12.4) and Suborbital Program (2.8) transferred to Environmental Observations

^{2/}Physics & Astronomy MO&DA/Explorer Ops. transferred to Environmental Observations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE AND APPLICATIONS

J O R F I G H T I T



PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of	Dollars)		
Space telescope development.....	121,500	137,500	137,500	120,600	RD 3-5
Gamma ray observatory development.. ...	8,000	34,500	34,500	89,800	RD 3-7
Shuttle/Spacelab payload development and mission management.....	47,556	83,000	83,000	92,900	RD 3-9
Explorer development.. ..	33,300	34,300	34,300	48,700	RD 3-11
Mission operations and data analysis..	45,300	73,200	74,800	79,500	RD 3-14
Research and analysis	22,935	26,800	28,800	29,800	RD 3-16
Suborbital program.....	<u>43,842</u>	<u>47,100</u>	<u>48,100</u>	<u>53,300</u>	RD 3-20
Total..... ..	<u>322,433</u>	<u>436,400</u>	<u>441,000</u>	<u>514,600</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center	4. 985	4. 775	8. 500	8. 650
Kennedy Space Center	2. 225	1,700	5. 005	7. 100
Marshall Space Flight Center	171. 180	222. 908	239. 529	229. 816
Goddard Space Flight Center	87. 863	149. 881	120. 567	194. 523
Jet Propulsion Laboratory	19. 309	17. 491	18. 243	20. 554
Ames Research Center	17. 230	17. 682	19. 345	21. 593
Langley Research Center	122	18	28	18
Headquarters	<u>19. 519</u>	<u>21. 945</u>	<u>29. 783</u>	<u>32. 346</u>
Total	<u>322. 433</u>	<u>436. 400</u>	<u>441. 000</u>	<u>514. 600</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECT / AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space-based research is being conducted to investigate the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, X-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, black holes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of data including the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM).

Explorer satellites are relatively low cost missions which have been developed since the beginning of our country's space program. The Infrared Astronomical Satellite (IRAS), developed in collaboration with the Netherlands and the United Kingdom to conduct the first survey of the far infrared sky, is scheduled to be launched in early 1983. The IRAS telescope is surrounded by superfluid liquid helium which keeps it at a temperature of 4 degrees above absolute zero, giving the mission the sensitivity to observe the cool and

cold objects of the universe. These objects include asteroids, regions of star formation, and non-thermal sources in some active galaxies which emit most of their radiation in the far infrared, the band between visible light, and microwaves. The International Ultraviolet Explorer has observed some very young stars, and these results are just now being applied to questions about the early history of the Earth. The Dynamics Explorers (DE) are continuing their investigations into the flow of energy into the Earth's magnetosphere: this information can be used to relate conditions at low latitudes to events occurring at high latitudes and far above the surface of the Earth. The Solar Mesosphere Explorer (SME) continues to relay data about the distribution of ozone high in the stratosphere: this data will be used to further our understanding of how it moves during the year as a result of solar activity.

In FY 1984, development activities on the Space Telescope will continue in preparation for launch in 1985. The detailed mechanical and electrical design of the Gamma Ray Observatory will be completed in FY 1984: Critical Design Reviews will be held on all the scientific instruments, and major hardware development will begin.

Two Explorer missions are now under development, the Active Magnetospheric Particle Tracer Explorers (AMPTE) and the Cosmic Background Explorer (COBE). In addition, a U.S. X-ray high-resolution imager is being developed for launch on the Roentgen Satellite (ROSAT), which is being developed by the Federal Republic of Germany. Development of the Extreme Ultraviolet Explorer (EUVE) will also be initiated in FY 1984. EUVE will survey the sky in the last unmapped spectral band by covering the portion of the electromagnetic spectrum between ultraviolet and X-rays.

Suborbital observations will continue to be conducted in FY 1984 from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere.

Two Spacelab payload missions, OSTA-1 and OSS-1, were successfully flown on Shuttle orbital flight tests. Spacelab 1 experiment integration activities have been completed in preparation for launch in September 1983, and significant progress has been made on development of the Spacelab 2 payload, the second of the two demonstration flights of the Spacelab hardware developed by the European Space Agency.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**SPACE TELESCOPE DEVELOPMENT**

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>1984</u> <u>Budget</u> <u>Estimate</u>
Spacecraft	91,200	110,000	114,200	100,400
Experiments	30,300	27,500	23,300	20,200
Total.....	<u>121,500</u>	<u>137,500</u>	<u>137,500</u>	<u>120,600</u>
Mission operations and data analysis..	(13,155)	(43,900)	(43,900)	(51,500)
Space transportation system operations	(800)	(11,200)	(7,500)	(14,200)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase, by several hundredfold, the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make possible observations of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the

observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Space Telescope we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy: it may also be possible to determine whether some nearby stars have planetary systems with the Space Telescope.

The Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Space Telescope design will permit in-orbit maintenance and repair, and/or retrieval by the Space Shuttle for return to Earth for required refurbishment and then relaunch by the Space Shuttle.

During FY 1982 the primary and secondary mirrors were coated and assembly of the primary mirror and its support equipment was begun. Fabrication of all scientific instruments has been completed: instrument assembly and environmental testing is underway. The Support Systems Module Critical Design Review was conducted, and fabrication of that major element is now in progress.

In 1983, the primary mirror assembly will be completed and integration of the Optical Telescope Assembly (OTA) will be initiated. The scientific instruments will be delivered for verification and acceptance testing. The Support Systems Module (SSM) will also be completed.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

In total, the FY 1983 current estimate for the Space Telescope remains the same as the budget estimate. However, within the project, more funding is required to solve technical challenges encountered on the spacecraft development. The scientific instruments development activities are proceeding satisfactorily.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding is required to complete the final integration and testing of the Optical Telescope Assembly, the Support Systems Module, and the scientific instruments. In addition, FY 1984 funding is required for integration and testing of the total Space Telescope system in preparation for the launch scheduled for 1985.

BASIS OF FY 1984 FUNDING REQUIREMENT:

GAMMA RAY OBSERVATORY DEVELOPMENT

	1982	1983		1984
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft	3,100	19,500	17,400	70,900
Experiments.	<u>4,900</u>	<u>15,000</u>	<u>17,100</u>	<u>18,900</u>
Total.....	<u>8,000</u>	<u>34,500</u>	<u>34,500</u>	<u>89,800</u>
Space transportation system operations.	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the Gamma Ray Observatory mission is to measure gamma radiation from the universe, and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored because the required technology has only recently been developed. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes. Astronomy is now at the point where our understanding of these objects is seriously impaired by lack of data in the gamma ray region of the spectrum. Comprehensive research in gamma ray astronomy has consistently been given high priority by the science community.

The ~~Gamma~~ Ray Observatory is scheduled for launch by the Space Shuttle in 1988. The spacecraft is being designed to accommodate four large gamma ray instruments, and will be designed to allow retrievability by the Space Shuttle. The instruments will have their principal axis pointing in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods (hours to weeks).

In FY 1982, procurement was initiated on long-lead items for the scientific instruments. Configuration drawings, resulting from studies of instrument placement and thermal requirements were completed. preliminary interfaces with the scientific instruments, the Space Shuttle, and the Tracking and Data Relay Satellite System were defined. In FY 1983, preliminary design reveiws for the scientific instruments will be completed; and procurement of long-lead spacecraft hardware will be initiated. Work will continue in FY 1983 on detailed definition of interfaces with the Space Shuttle, and spacecraft design will be well underway.

CHANGES FROM FY : BUDGET ESTIMATE:

In total, the FY 1983 current estimate for the ~~Gamma~~ Ray Observatory remains the same as the budget estimate. However, within the project, funding has been shifted from experiments to the spacecraft development efforts to bring the two activities more in line with one another.

BASIS FOR FY 1984 ESTIMATE:

The FY 1984 funding is required to complete the detailed mechanical and electrical designs; complete the critical design reviews on the scientific instruments; and complete the spacecraft preliminary design review. Spacecraft and scientific instruments hardware fabrication will also be initiated in FY 1984.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

2 A PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

	<u>1982 Actual</u>	<u>1983 Budget Estimate (Thousands of</u>	<u>Current Estimate Dollars)</u>	<u>1984 Budget Estimate</u>
Pay load deve lopment and mission management.... ..	47,556	83,000	83,000	92,900

OBJECTIVES AND STATUS:

The objectives of Spacelab payload development and mission management are to acquire new knowledge in the disciplines of physics and astronomy, to develop instruments for materials processing experimentation, and to manage the mission planning and execution of all NASA Spacelab payloads. This funding is required for the development of all physics and astronomy experiments, system management and engineering development of flight equipment and software; payload specialist training and support; physical integration of the payloads with the Spacelab system; operation of the payload in flight; dissemination of the data to experimenters; analysis of physics and astronomy flight data. In addition, this project funds the mission management efforts for all NASA Spacelab payloads.

Instruments to be flown on four missions with primary emphasis on physics and astronomy are now under development. Spacelab-1, which will consist of a pressurized module and a pallet, is scheduled for launch in 1983. The objectives of Spacelab-1 are to demonstrate the capabilities of the Spacelab system and to obtain multidisciplinary scientific data with emphasis on atmospheric and space plasma physics, as well as life sciences. Spacelab-1 is a cooperative mission with the European Space Agency. In 1983, the Spacelab-1 instruments will be integrated into the Spacelab module and pallet system and then into the Shuttle. Spacelab-2, a pallet-only configuration, is scheduled to fly in early 1985. The objective of Spacelab-2, the second of the two demonstration Spacelab flights, is to verify the Spacelab igloo and pallet systems and obtain scientific data with emphasis on astrophysics and solar physics. The Instrument Pointing System, developed by the European Space Agency, will be flown for the first time on the Spacelab-2 mission. During FY 1983, development of the Spacelab-2 instruments will be completed and integration will be initiated.

The OSS-5 mission is also under development with launch scheduled for 1986. OSS-5 is a Spacelab pallet payload consisting of three ultraviolet telescopes that will carry out ultraviolet imaging, spectrophotometry, and polarimetry at resolutions and sensitivities previously unavailable. This payload will allow unique new scientific investigations of a broad range of objects from nearby comets and planets to the most distant quasars. Data gathered by the OSS-5 mission will be used to define and direct future Space Telescope observations. The first flight of this mission will occur during the period of Halley's Comet and will allow unique scientific observations of the comet from a near-Earth orbital environment.

The Solar Optical Telescope (SOT) facility instrument definition and early design is now underway. The SOT will have a broad scientific capability and will accommodate a number of principal investigator-furnished focal plane or ancillary instruments.

Definition and development schedules of all physics and astronomy instruments are phased to form scientifically focused payloads. Instruments currently under development will be refurbished and reflown on future Spacelab missions, thereby significantly increasing the scientific value of the original investment. The hardware development efforts for the Fluid Experiment System/Vapor Crystal Growth payload are now being funded under this area to be more consistent with the Space Science and Applications organizational responsibilities. It was previously funded under the Materials Processing activities within Space Applications.

At the Kennedy Space Center, a system has been established to assemble Spacelab hardware to form a mission payload and to test the integrated system. Mission management activities are continuing on several space science and applications and space technology missions, as is planning for the first dedicated Life Sciences Spacelab mission.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, mission management of the ongoing Spacelab missions will be continued. Mission management for the non-physics and astronomy missions includes all Spacelab payload efforts except instrument development and data analysis. FY 1984 funding is also required to continue development of instruments for materials processing experimentation including the Fluid Experiment System/Vapor Crystal Growth experiment, which is planned for flight on Spacelab-3.

FY 1984 funding is required for analysis of data from the Spacelab-1 mission, as well as integration and test activities on the Spacelab-2 payload, leading to a launch in 1985. Development will continue in FY 1984 on the instruments for the OSS-5 mission as well as on the Solar Optical Telescope. Early definition activities will be continued on the Shuttle Infrared Telescope Facility. FY 1984 funding is also required to define potential payloads for a future Space Station.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**EXPLORER DEVELOPMENT**

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Dynamics explorer	596	---	---	---
Infrared astronomical satellite.....	14,944	---	6,600	---
Active magnetospheric particle tracer				
explorer	11,794	11,700	11,700	4,300
Cosmic background explorer	1,000	16,100	11,500	26,300
Roentgen satellite.....	300	---	2,500	2,000
Extreme ultraviolet explorer	---	---	---	11,000
Other explorers	<u>4,666</u>	<u>6,500</u>	<u>2,000</u>	<u>5,100</u>
Total.....	<u>33,300</u>	<u>34,300</u>	<u>34,300</u>	<u>48,700</u>
Mission operations and data analysis..	(13,704)	(15,950)	(15,140)	(14,600)
space transportation system operations.	(7,800)	(6,300)	(6,000)	(100)

OBJECTIVES AND STATUS:

The Explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment, having limited specific objectives and not requiring major observatories. Included in the present program are studies of the atmospheric and magnetospheric physics: the several magnetospheric boundaries; interplanetary phenomena; and x-ray, ultraviolet and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving the mission objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1983 include launch of the Infrared Astronomical Satellite, launch of the San Marco-D mission, and continuation of development on the Active Magnetospheric Particle Tracer Explorer. The San Marco-D mission, a cooperative project with Italy, will include a group of United States experiments to study the relationship between solar activity and the Earth's meteorological phenomena. The Infrared Astronomical Satellite, a cooperative project with the Netherlands and the United Kingdom, is expected to record precise flux levels and locations of over a million infrared sources in the universe. The Active Magnetospheric Particle Tracer Explorer, a cooperative project with the Federal Republic of Germany, will involve the use of two spacecraft, one designed and built by the United States and one designed and built by Germany. The mission will study the solar wind at the subsolar point and will identify particle entry windows, energization processes and transport processes into the magnetosphere.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, X-ray, ultraviolet and low frequency radio regions of the electromagnetic spectrum. The Cosmic Ray Isotope Experiment, which was launched in May 1982 on a Department of Defense spacecraft, is studying galactic cosmic rays, as well as nuclei accelerated from solar flares, in order to shed light on models of nucleosynthesis and to identify probable sources of cosmic ray nuclei. Development will continue on the Cosmic Background Explorer (COBE) and on the instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the diffuse cosmic background radiation of the universe between the wavelengths of 1 micrometer and 13 millimeters. The detailed information this mission will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insight into the basic cosmological question of the origin and evolution of the universe. ROSAT, a cooperative project between the Federal Republic of Germany and the United States, will perform high resolution imaging studies of the X-ray sky. The United States will provide a high resolution imaging instrument and launch services, and Germany will provide the spacecraft and instrumentation.

FY 1983 funding is also supporting definition studies for future candidate explorer missions, including the Extreme Ultraviolet Explorer which will be initiated in FY 1984, the X-Ray Timing Explorer, and instrumentation to be flown on the reflight of the Long Duration Exposure Facility which will be a Cosmic Ray Mission.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

In total, the FY 1983 current estimate for the Explorer Development remains the same as the budget estimate. However, within the project, funding has been shifted around to accommodate the slip of the IRAS launch from late 1982 to early 1983, and to accommodate the development of instrumentation to fly on the German Roentgen Satellite. These changes were accommodated by the later than planned initiation of the Cosmic Background Explorer development plus a decrease in the definition efforts for future potential Explorer missions.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funding is required for continued development activity on the Atmospheric Particle Tracer Explorer, the Cosmic Background Explorer, and instrumentation to be flown on the German Roentgen Satellite, as well as initiation of development on the Extreme Ultraviolet Explorer. The Extreme Ultraviolet Explorer will carry out the first detailed all sky survey of ultraviolet radiation between 100 and 900 angstroms--a hitherto unexplored portion of the electromagnetic spectrum. FY 1984 funding will also provide for definition studies of potential future explorer missions such as the X-ray Timing Explorer.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**MISSION OPERATIONS AND DATA ANALYSIS**

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>1984</u> <u>Budget</u> <u>Estimate</u>
High energy astronomy observatory extended mission.....	5,267	2,050	3,502	5,000
Solar maximum mission basic mission...	595	---	---	---
Solar maximum mission extended mission.....	2,937	2,100	2,683	2,100
Solar maximum mission retrieval/ repair mission.....	9,000	9,200	9,200	6,300
Space telescope operations	13,155	32,800	32,800	38,000
Space telescope maintenance and refurbishment.....	---	11,100	11,100	13,500
Explorers	13,704	15,950	15,140	14,600
Orbiting astronomical observatory.	<u>642</u>	<u>---</u>	<u>375</u>	<u>---</u>
Total.....	<u>45,300</u>	<u>73,200</u>	<u>74,800</u>	<u>79,500</u>

OBJECTIVES AND STATUS:

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data from the physics and astronomy satellites after launch. The program also supports the continued operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities, are typically carried out under a variety of mission support or center support contracts.

Several spacecraft remain operational. The International Ultraviolet Explorer continues to perform well, with a very productive guest investigator program. The Solar Maximum Mission (SMM) also continues to provide useful data, even though it is operating in a degraded mode. Mission operations and data analysis will continue for these missions through FY 1983, as well as for the Infrared Astronomical Satellite, which will be launched in early 1983. FY 1983 funding also supports activities leading to the retrieval/repair of the SMM spacecraft and science instruments in 1984.

In addition to the normal support required for mission operations, the Space Telescope program encompasses several unique aspects which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, using the STS for in-orbit maintenance, refurbishment, and in-orbit changeout of the scientific instruments as well as periodic retrieval, return to Earth for complete refurbishment, and then relaunch by the Space Shuttle. During the operational period, the Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations will be carried out through an independent Space Telescope Science Institute. The institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Space Telescope.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$1.6 million reflects additional appropriations over the FY 1983 budget request. These additional appropriations will be used primarily to continue analysis of data from the highly productive High Energy Astronomy Observatories, the Orbiting Astronomy Observatory, and the Solar Maximum Mission.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funds will provide support for the basic mission operations and data analysis activities for the Infrared Astronomical Satellite and the Active Magnetospheric Particle Tracer Explorer, continued operations and data analysis activity for the International Ultraviolet Explorer, and continued analysis of the extensive data obtained by the High Energy Astronomy Observatory missions. FY 1984 funding will support the retrieval/repair of the Solar Maximum Mission spacecraft and instruments, and will support preparations for the operation of the Space Telescope. In FY 1984, the development of mission operations procedures as well as development of the science operations ground system for the Space Telescope will be continued. The Space Telescope Science Institute will progress toward becoming operational through the continued development of the Guide Star Selection System and Science Data Analysis Software. In FY 1984, maintenance and refurbishment planning activities such as the purchase of orbital replacement units and space support equipment will be continued to allow for the capability to service the Space Telescope in orbit.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	<u>1984</u> Budget <u>Estimate</u>
Supporting research and technology	15,309	19,400	20,400	19,900
Advanced technology development.....	3,950	2,500	3,500	4,700
Data analysis	<u>3,676</u>	<u>4,900</u>	<u>4,900</u>	<u>5,200</u>
Total.....	<u>22,935</u>	<u>26,800</u>	<u>28,800</u>	<u>29,800</u>

OBJECTIVES AND STATUS:

This program provides for the research and technology base necessary to define, plan and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

- o Supporting Research and Technology (SR&T): The objectives of the supporting research and technology area are to: (1) optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; and (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to support our understanding of astrophysics and solar-terrestrial relationships.

Research is supported in the disciplines of astronomy, astrophysics, and solar and heliospheric physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The work in solar and heliospheric physics involves the study of

the solar atmosphere and the influence of the Sun on interplanetary phenomena. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SR&T program have a direct bearing on future flight programs. For example, the development of advanced X-ray and ultraviolet astronomy imaging devices under this program will enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

- o Advanced Technological Development (ATD): The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems and elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility (AXAF), the Solar Internal Dynamics Mission (SIDM), and the Starprobe. The AXAF mission, which is the first priority mission recommendation of the National Academy of Sciences, will study stellar structure and evolution, active galaxies, cluster of galaxies and cosmology. The AXAF's 1.2 meter class imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SIDM will observe the oscillations visible on the Sun and use the data to investigate the dynamics of the Sun's interior to provide insight into solar and stellar interior structure. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within three solar radii of the Sun's surface.

Major Spacelab payloads being considered for future proposal and requiring advanced technological development support include the following multiuser facilities: the Pinhole/Occulter Facility, a coded mask and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class ultraviolet/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space

Telescope. During FY 1983, major emphasis is being given to definition of the AXAF mission, while definition work is also continuing on Spacelab instruments and facilities, including detailed description of payload configurations and operational requirements.

- o Data Analysis: The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data are correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to extract a maximum amount of information from the data they obtained from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices (CCD's) now being ground-tested for use on the Space Telescope.

Operation of the National Space Science Data Center (NSSDC) is also supported under this program. The NSSDC, located at the Goddard Space Flight Center, was established to serve as a central repository and clearing house for scientific data resulting from space investigations. The NSSDC is now in a state of transition from a repository to a facility where correlative research can be accomplished by using data sets from many sources, including active spacecraft, so that data acquisition and analysis efforts can be coordinated at times when several spacecraft are favorably situated for correlative geophysical studies.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.0 million increase reflects a general appropriation addition to the FY 1983 budget request, which will be used primarily to enhance university research efforts in detector development activities in the areas of gamma ray spectroscopy, infrared astronomy, and solar physics.

BASIS OF FY 1984 ESTIMATE:

During FY 1984, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detector development and on expansion of technology activities related to large X-ray mirrors, advanced X-ray detectors, gamma ray spectrometers and instrumentation. Emphasis will also be placed on the development of a large array multichannel plate, and on intensified charge-coupled imagery devices. In the area of solar

physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. New thrusts will be initiated in the development of advanced generation instrument concepts, especially for the extreme ultraviolet and X-ray wavelengths, and for analyzing the structure and dynamics of the solar interior.

In the data analysis activities to be carried out at universities and government research centers in FY **1984**, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft and ground observatories). FY **1984** funds will also support the continued operation of the National Space Science Data Center at the Goddard Space Flight Center. In addition, FY **1984** funding will support continued feasibility and scientific definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility, Gravity Probe-B, the Starprobe and the Solar Internal Dynamics Mission, as well as the definition of new Spacelab payloads.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Sounding rockets.....	24,414	26,000	27,000	27,700
Airborne science and applications	17,525	17,600	17,600	18,900
Balloon program	<u>1,903</u>	<u>3,500</u>	<u>3,500</u>	<u>6,700</u>
Total.....	<u>43,842</u>	<u>47,100</u>	<u>48,100</u>	<u>53,300</u>
Sounding rockets.....	24,414	26,000	27,000	27,700

OBJECTIVES AND STATUS:

The suborbital program provides versatile, relatively low cost research through the use of balloons, aircraft, and sounding rockets to study the Earth's ionosphere and magnetosphere, space plasma physics stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis.

A primary objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and

space probes, and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In FY 1982, 45 rockets were launched from six launch ranges located in the United States, Canada, and Norway. These rockets supported the research activities of about 27 groups from over 20 universities, private industry, NASA field centers, other government agencies and foreign space organizations.

During FY 1982 an astronomy sounding rocket payload, using a prototype telescope, obtained the first ultraviolet image of a barred spiral galaxy, Messier #83. This observation is significant in that the results indicate the presence of a massive black hole, whereas ground observations show a very ordinary galaxy. Additional sounding rocket activity, in support of auroral studies, has produced new results showing that X-rays are produced from electrons striking the upper atmosphere and that large electrical fields exist in the middle atmosphere. The origin of these fields remains a mystery.

Sounding rocket support for the area of plasma physics will continue to be of significant importance in FY 1983, with a coordinated international campaign of launches planned from Peru. These investigations will provide correlative data on the Earth's magnetosphere.

In FY 1983, emphasis is being placed on a sounding rocket payload concept called "Spartan". Under this concept, the capabilities of the Shuttle are made available to sounding rocket experiments, which will potentially increase scientific data acquisition periods from the present five minutes per flight up to 40 hours. The Spartan concept calls for sounding rocket scientific instrumentation and support hardware to be carried aloft by the Shuttle as free-flying payloads, and then returned by the Shuttle. These payloads require a minimum interface with the Shuttle. Development efforts on two payloads are being conducted in FY 1983, one for high energy astrophysics and one for solar astronomy.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$1.0 million increase in the Suborbital program reflects a general appropriation addition to the FY 1983 budget request which will be used primarily to implement the Spartan concept wherein sounding rocket-class payloads will be flown on the Space Shuttle to obtain longer periods of time for sounding rocket scientific investigations.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funds will provide for continuation of the efforts described above, including development activity leading to a planned initial launch of a Spartan payload in 1984.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Airborne science and applications.. ...	17,525	17,600	17,600	18,900

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. For astronomy research, the airborne science and applications program utilizes a C-141 instrumented with the 91-centimeter infrared telescope. The C-141A "Kuiper Airborne Observatory," which began operational flights in 1974, is a full-scale, manned facility. This aircraft provides a large payload capacity and facilities for extending observations over any region of the Earth, and can operate at high altitudes (nearly 13 kilometers), in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in opening the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers to astronomy.

In FY 1982, 62 flights were flown to make far-infrared observations. In FY 1983, approximately 72 flights of the C-141 will be made to continue exploration in the star-forming regions. A scientific highlight will be an expedition to Australia to observe the center of our own galaxy in the far infrared.

This program also provides flight support to other major segments of the Space Science and Applications program, with an aircraft fleet currently consisting of two U-2C's, one ER-2, one C-130, and one CV-990, in addition to the C-141A. These aircraft serve as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites. The data acquired during these flights are used to refine algorithms and develop ground data handling techniques. Examples of such activities are flights over test sites to obtain crop signature data for the AgRISTARS program by the C-130, and flights in the ER-2/U-2C's to acquire simulated thematic mapper data. A principal use of the ER-2/U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below that of orbiting spacecraft. This use is important in the study of stratospheric transport mechanisms wherein it is extremely desirable to penetrate the stratospheric region which, in the tropical interconvergence zone, is normally found at altitudes of 60,000 feet and above.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, airborne science and applications funding is required to continue the operation of the Kuiper Airborne Observatory, to support astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Balloon program.....	1,903	3,500	3,500	6,700

OBJECTIVE AND STATUS:

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared and cosmic ray astronomy. In many instances it is necessary, because of size and weight, as well as low cost, to fly these experiments on balloons.

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, and maintenance and operation of the National Scientific Balloon Facility (NSBF) at Palestine, Texas. This facility supports the launch of over 95 percent of **NASA's** balloon payloads. It is the nation's primary means for carrying out large scientific balloon operations. NASA took over funding responsibility for the NSBF from the National Science Foundation at the beginning of FY 1983. Funding for the experiments which are flown on these balloons is provided from supporting research and technology programs.

In FY 1982, 54 balloons were flown from launch sites in the United States, Brazil, and Australia. Over 90 percent of the flights originated from the United States. Launches from the southern hemisphere permit viewing of the galactic center, a prime area of interest to high energy astrophysics investigators. Results from these flights have provided clear evidence which supports the possibility that a massive black hole exists in the center of our galaxy.

During September 1982, a major balloon campaign was launched from Palestine, Texas, in support of atmospheric chemistry investigations. This seven-nation cooperative program to measure chemical constituents in the stratosphere required the launch of four heavy lift balloon payloads within three and

one-half hours. This program, known as the Balloon Intercomparison Campaign, is significant in that it provided a complete set of measurements on key chemical constituents of a well defined air mass.

In FY 1983, approximately 50 balloon flights are planned to continue scientific research in the areas of atmospheric chemistry, high energy astrophysics, galactic astronomy and solar studies. The Balloon Intercomparison Campaign will be continued to study the chemical constituents of the stratosphere, and a high energy astrophysics program of observations of the galactic center will be continued.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding will provide for the continuation of the balloon program as well as management and operation of the NSBF. This funding is also required to continue concept definition activities for potential future long duration balloon flights.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of Dollars)	1983 <u>Current Estimate</u> (Thousands of Dollars)	1984 <u>Budget Estimate</u>	Page <u>Number</u>
Life sciences flight experiments	14,000	24,000	24,000	23,000	RD 4-5
Research and analysis	25,500	31,700	31,700	36,000	RD 4-7
Total.....	<u>39,500</u>	<u>55,700</u>	<u>55,700</u>	<u>59,000</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	12,742	20,964	19,221	20,032	
Kennedy Space Center.....	938	1,525	1,485	1,550	
Marshall Space Flight Center.....	72	350	250	267	
Goddard Space Flight Center.....	---	---	80	86	
Jet Propulsion Laboratory... ..	1,136	2,732	1,028	1,102	
Ames Research Center.....	17,048	21,351	22,007	23,128	
Langley Research Center.....	253	170	421	452	
Headquarters	<u>7,311</u>	<u>8,608</u>	<u>11,208</u>	<u>12,383</u>	
Total.....	<u>39,500</u>	<u>55,700</u>	<u>55,700</u>	<u>59,000</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LIFE SCIENCES PROGRAM

I. OBJECTIVES AND JUSTIFICATION

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding the response of biological systems to weightlessness; the design of advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, its origin, evolution, and present state.

The Life Sciences program is the key to developing a capability to sustain a permanent manned presence in space and utilizing the space environment to study living systems. These efforts include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes several major elements: operational medicine which is focused on the health and well being of Space Shuttle crews; biomedical research which is directed toward understanding and preventing any adverse physiological changes which occur in space flight; advanced life support system, which is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time; space biology which consists of flight and ground-based experiments that focus on using microgravity as a biological research tool to understand its effect on plants and animals; exobiology research which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and global biology research which is directed toward understanding the interaction between life on Earth and its physical and chemical environment.

The goals of the Operational Medicine and Biomedical Research programs are to assure astronaut and payload specialist health and ability to function effectively in the space environment. Eventually, experience gained from the medical operations support to space flight will allow a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is being placed on testing countermeasures designed to prevent physiological problems associated with exposure to the space environment. It is essential that long-term monitoring of spaceflight crews be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: vestibular dysfunction, behavioral changes, cardiovascular deconditioning, bone and muscle loss, and radiation damage. This research concentrates on trying to define potential flight experiments and countermeasures for use during spaceflight.

The Advanced Life Support System program supports activities ranging from the development of less constraining and more efficient space suits and life support systems for the astronauts, to scientific work in chemistry and biology necessary to understand how life can be maintained in systems which receive only energy from the external environment. All are aimed at potential future needs of long duration manned space flight.

The objective of Space Biology activities is to further our understanding of basic physiological mechanisms through the use of microgravity and the space environment. Plant and animal experiments have been flown on three Soviet Cosmos satellites and on the Shuttle orbital flight tests; experiments are under development for all Shuttle flights up through the Spacelab 4 mission. These experiments will explore the physiological effects of space flight on inner ear function, blood factors, bone formation, and plant growth and structure. The information obtained should contribute to the solution of biological and medical problems on Earth as well as contribute to man's effective functioning in space. The unique properties of space (e.g., microgravity) provide an opportunity to explore significant problems in biology under controlled conditions that cannot be duplicated in laboratories on Earth.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sound hypotheses which could lead to discovering the relationships which may link the beginnings of life to the formation of the solar system and the Earth itself. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with the results of flight experiments, are clarifying the mechanisms and environments conducive to the formation of essential biomolecules.

Studies of life's origin and evolution must be extended to enhance our understanding of the interaction of the biota with the Earth's present environment, and thereby provide a more comprehensive picture of life--its past, present, and future.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of Dollars)	1983 <u>Current Estimate</u> (Thousands of Dollars)	1984 <u>Budget Estimate</u>
Life sciences flight experiments	14,000	24,000	24,000	23,000

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to assimilate information and questions from the various life sciences disciplines and translate them into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting of medical and biological investigations. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth; however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these changes may prove irreversible. Early Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early physiological response to weightlessness, which will improve the management of several existing problems (e.g., space motion sickness) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities involve the development of life sciences flight experiments to be flown on Spacelab-1 and 2, and the German-D1 mission (Spacelab-D1). Most of the experiments onboard the early Shuttle flights will serve as pathfinding activities for Spacelab-4, the first Spacelab mission dedicated entirely to life sciences investigations. Hardware and experimental protocols for flights through Spacelab-2 are well developed. Activities on Spacelab-3 will involve evaluation of functional performance and biocompatibility of hardware that is essential to human and animal investigations which will be conducted on Spacelab-4. Hardware development and mission planning activities are proceeding on schedule for the United States vestibular experiment which will be flown on the German-D1 (Spacelab-D1) mission.

Twenty-five investigations have been tentatively selected as the scientific payload for Spacelab-4. The definition phase activities have been completed leading to final payload selection, and initiation of design and development of the flight hardware has begun. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight through the use of both human and animal subjects. Teams of principal investigators will examine cardiovascular adaptation, space motion sickness, muscle wasting, demineralization of bone, and the early anemia of weightlessness. This mission will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences; it will involve highly skilled scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space; and the experiments will employ complementary human and animal investigations in order to validate models for human physiology.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funding is required for the continuing definition and development of hardware which will be flown on future Spacelab missions, i.e., Spacelab-3, D1, and 4. Flight hardware integration and experiment development associated with Spacelab-2, 3, and D1 will be completed in preparation for launches in 1984 and 1985. Final experiment selection of investigations for the first life sciences dedicated mission (Spacelab-4) will be completed and experiment design and development of associated hardware will be initiated. In addition, the selection process for experiments for the follow-on dedicated Spacelab life sciences mission will be initiated.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>1984</u> <u>Budget</u> <u>Estimate</u>
Life sciences research and analysis ...	25,500	31,700	31,700	36,000

OBJECTIVES AND STATUS:

The research and analysis activity of the Life Sciences program is concerned, in part, with ground-based research in biological and medical problem areas that have been identified in previous manned flights. The program is comprised of six elements: (1) operational medicine; (2) biomedical research; (3) advanced life support systems research; (4) space biology; (5) exobiology; and (6) global biology.

The Life Sciences Operational Medicine program is responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. This includes assuring physical welfare, performance, and adequate treatment of in-flight illnesses or injuries. Such manifestations as space disorientation, fluid shifts, and endocrine shifts, which can cause decreased performance in flight, as well as decreased cardiovascular tolerance and possible aggravation of latent diseases, will be carefully documented with the goal of future prevention or mitigation to the extent possible. To this end, specific operational requirements such as careful medical selection, periodic evaluation of health status (including pre- and post-flight medical observation), and in-flight monitoring of the time course of adaptation and performance in the space environment will be continually reevaluated and updated.

The Biomedical Research program seeks to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, each designed to rectify a particular physiological problem known or expected to affect the human organism in space. Such problems as motion sickness, bone loss, and electrolyte imbalances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventive

measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space.

The Advanced Life Support Systems research program concentrates on enhancing our ability to support long-duration manned presence in space and on optimizing the productivity of mixed spacecraft crews. Improvements are sought in spacecraft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for new systems such as food recycling for long-term missions. Research is in progress on space suits for quick reaction situations and on innovative approaches to designing space tools and work stations.

The Space Biology program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal behavior, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth as well as long-term survival and multigeneration reproduction of life in space. This program provides important ground-based information needed to develop future space flight experiments and life support systems.

The Exobiology program is directed toward furthering our understanding of the origin and evolution of life and life-related molecules, on Earth and elsewhere in the universe. Research, in general, builds on data acquired by missions in planetary exploration and astrophysics to uncover the relationship between the origin and evolution of the solar system and life itself. Theoretical and laboratory investigations are **also** included in this program to develop a better understanding of the conditions on the primitive Earth as related to early chemical and biological evolution.

The Global Biology program explores the interaction between the biota and contemporary environment to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes on global dynamics. Biospheric modelling efforts focus on integrating biology with atmospheric, climate, oceanic, terrestrial, and bio-geochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the Operational Medicine program will, investigate and collect information on occupational exposures in zero-gravity on each Shuttle flight; conduct inflight clinical testing of countermeasures especially in the areas of cardiovascular deconditioning and vestibular problems, and develop health care procedures compatible with the space environment. Annual and pre- and post-flight medical data will be collected in order to better define responses of different population groups to space flight.

In FY 1984, the Biomedical Research program will focus primarily on problems related to vestibular dysfunction because of their relevance to Shuttle operations. Psychology, human factors, and the enhancement of performance are all receiving increased emphasis. Studies of bone loss and of electrolyte imbalance will also be pursued so that potential countermeasures can be devised. Increased awareness and understanding of a potential radiation hazard from space flight has resulted in more emphasis being placed on the precise measurement of radiation doses, the specific biological effects of cosmic rays, and the identification of possible radiation shielding.

In FY 1984, the Advanced Life Support Systems program will continue to investigate basic biological processes and physical/chemical methods which will provide capabilities to recycle air, water, food and wastes; and continue definition of concepts for improved space suits and portable life support systems.

In FY 1984, the Space Biology program will focus on continuation of research directed at understanding animal and plant equilibrium, gravity perception, and biotransduction mechanisms, as well as gravity's effect on plant and animal development, structure, and behavior. Increased emphasis will be placed on research that will lead to the development of hypotheses, and provides baseline data for future Shuttle/Spacelab flight experiments.

In FY 1984, the Exobiology program emphasis will be placed on the continuation of such efforts as expanding our knowledge of non-biological mechanisms of synthesis of biologically significant molecules both in space and on the Earth. This research is crucial for gaining further insight into the origin of life as well as assessing the possibility of these processes occurring elsewhere in the universe.

In FY 1984, the Global Biology research program will place emphasis on improving our estimating techniques for determining the size and distribution of the terrestrial biomass by combining ground-based measurements with remote sensing data. Additional emphasis will be placed on characterizing biogenic gas fluxes of key atmospheric constituents. This information is required for development of a better understanding of global bio-geochemical cycles.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, emphasis will also be placed on the formulation of improved approaches to the operational management of space adaptation. Based on current research, in-flight evaluation of these concepts will be conducted which will, in turn, allow improved countermeasures to be produced. Improved pre-flight testing and in-flight evaluation of biofeedback and drug therapy techniques are presently under definition. A middeck rotator will be used on the Shuttle as part of a series of studies which will investigate the inflight effectiveness of various countermeasures. Definition of compatible ground and flight research theories and proposed techniques is planned.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PLANETARY EXPLORATION I

SUMMARY OF RESOURCES REQUIREMENTS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of	Dollars)		
Galileo development.. .. .	115,700	92,600	91,600	79,500	RD 5-4
Venus radar mapper mission.....	---	---	---	29,000	RD 5-6
International solar polar mission.. ...	5,000	21,000	6,000	8,000	RD 5-8
Mission operations and data analysis..	42,600	26,500	38,500	43,400	RD 5-10
Research and analysis	46,700	35,500	50,300	45,500	RD 5-12
Total.....	<u>210,000</u>	<u>175,600</u>	<u>186,400</u>	<u>205,400</u>	

Distribution of Program Amount by Installation:

Johnson Space Center.....	6,887	8,900	7,307	6,800
Marshall Space Flight Center.. .. .	143	---	---	---
Goddard Space Flight Center.....	3,921	3,500	5,483	4,336
Jet Propulsion Laboratory.....	132,936	139,200	120,158	139,040
Ames Research Center.....	33,551	12,000	17,136	12,253
Headquarters	32,562	12,000	36,316	42,971
Total.....	<u>210,000</u>	<u>175,600</u>	<u>186,400</u>	<u>205,400</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Planetary Exploration program includes the scientific exploration of the solar system, including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the outer planets, and to understand how the appearance of life in the solar system is related to the chemical history of the solar system. The projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the terrestrial-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these planetary bodies start at the level of reconnaissance to achieve fundamental characterization of the bodies and proceed to a level of detailed study. The reconnaissance phase of inner planet exploration began in the 1960's and has now been completed, though we still know little about the nature of the planet Venus' surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a new level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of the moon rock samples returned by Apollo continue to be highly productive as new insights into the early history of the inner solar system are achieved and our theoretical concepts are revised accordingly. The continuing Pioneer Venus mission is carrying the study of our nearest neighbor and closest planetary analogue beyond the reconnaissance stage to the point where we have produced a basic characterization of the massive cloud-covered atmosphere of Venus. The characterization has also provided some fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently. The Pioneer-10 and 11 flybys of Jupiter in 1973 and 1974 were followed by the Voyager-1 and 2 spacecraft. Voyager-1 encountered Jupiter in March 1979 and Saturn in November 1980. Voyager-2 flew by Jupiter in July 1979 and Saturn in August 1981. New data on the planets, satellites and rings have revolutionized our concepts of the formation and evolution of the solar system. The Voyager-2 spacecraft is headed for an encounter with Uranus in 1986 that will further our knowledge of the giant outer planets as well as capitalize on the significant scientific, engineering and financial investment made in the development of the Voyager systems. The Pioneer-10 and 11 and Voyager-1 spacecraft are on trajectories leading out of the solar system, and they continue to return

scientific data on the outer reaches of the solar system. Our scientific knowledge of the outer planets has increased greatly in less than a decade.

The Galileo mission will be launched to Jupiter in 1986 by the Space Shuttle/Centaur Upper Stage. The payload is expected to extend our knowledge of Jupiter and its system of satellites beyond the profound discoveries of the Voyager and Pioneer missions. During twenty months of operation in the Jovian system, Galileo will have the capability to provide six satellite encounters, and an instrumented probe will be injected into Jupiter's atmosphere.

The Venus Radar Mapper (VRM) mission, which will be initiated in FY 1984, will focus on the cloud-shrouded surface of Venus. The VRM, using a synthetic aperture radar, will obtain global radar imagery of Venus with resolution sufficient to address fundamental questions regarding the origin and evolution of the planet, and will obtain altimetric and gravity data to determine accurately the gravity field, internal stresses, and density variations of the planet's interior. This data will be analyzed so that the evolutionary history of Venus can be compared with the Earth's. The VRM is scheduled for launch in 1988.

The International Solar Polar Mission (ISPM) is a joint NASA and European Space Agency endeavor that will fly a package of experiments outside the solar ecliptic plane. The ISPM, which will provide data on the effects of solar activity on the Earth, will be launched in 1986 on the Shuttle/Centaur Upper Stage.

In addition, the Planetary Exploration program is founded on a coordinated research and analysis program. Research and analysis activities will continue to be undertaken to maximize the scientific return from ongoing and future missions, such as lunar sample and meteorite analysis, ground-based telescope observations, theoretical and laboratory studies, and instrument definition. The highest scientific standards are maintained in these programs and both new and old concepts are subject to intense scrutiny. This program also involves interdisciplinary coordination among various research groups and the scientific results are widely disseminated. A close coupling is maintained between the research programs and the planning activities that are undertaken to define the scientific rationale and technology needed for potential future missions.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

GALILEO DEVELOPMENT

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1984</u> <u>Budget</u> <u>Estimate</u>
Spacecraft	90,500	68,600	67,600	48,800
Experiments	13,500	8,000	8,000	4,500
Ground operations	<u>11,700</u>	<u>16,000</u>	<u>16,000</u>	<u>26,200</u>
Total.....	<u>115,700</u>	<u>92,600</u>	<u>91,600</u>	<u>79,500</u>
Space transportation systems operations	(8,200)	(35,800)	(11,300)	(35,300)

OBJECTIVES AND STATUS:

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and direct measurements by an atmospheric probe. The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance, and orderly progression of the exploration of the solar system.

The Galileo mission will be accomplished with a single launch of both the orbiter and probe by the Shuttle/Centaur in 1986. Arrival at Jupiter will be in late 1988. The orbiter will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. The total duration of the mission will be approximately four years.

The Galileo system will consist of an orbiter, a probe, and an upper stage adapter to accommodate integration of the Galileo system with the Centaur upper stage. The flight system will be powered by two general purpose heat-source radioisotope thermoelectric generators (RTG's) being developed by the Department of Energy. The orbiter will carry approximately 100 kg of scientific instruments and the probe will carry approximately 25 kg of scientific instruments.

During FY 1983, major activities on the Galileo program will involve completion of the orbiter subsystems and initiation of the orbiter spacecraft integration. In FY 1983, the probe will be integrated and environmental testing will be accomplished, leading to integration with the orbiter in 1984.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The FY 1983 estimate reflects a reduction of \$1.0 million. The change from a planned Inertial Upper Stage (IUS) launch in 1985 to a Centaur launch in 1986 made the development of a kick stage to accommodate the Galileo orbiter and probe launch on an Inertial Upper Stage no longer necessary. There is, however, the requirement to develop an adapter to permit the Galileo spacecraft to be integrated with the Centaur.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding will provide for the integration of the Galileo orbiter and environmental testing of the entire system. Development of the ground systems required to support operation of the spacecraft will also be continued. In addition, the FY 1984 funding is required to reimburse the Department of Energy for the continued development of the radioisotope thermoelectric generators.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

VENUS RADAR MAPPER MISSION

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Spacecraft	---	---	---	14,200
Experiments	---	---	---	11,600
Ground operations	---	---	---	3,200
Total	---	---	---	29,000
Space transportation systems operations	(---	(---	(---	(---

OBJECTIVES AND STATUS:

The Venus Radar Mapper (VRM) mission will be initiated in FY 1984. The mission objectives are to address fundamental questions regarding the origin and evolution of the planet Venus by obtaining global radar imagery of the planet. VRM will obtain altimetric and gravity data to determine accurately the gravity field, internal stresses, and density variations of the planet's interior. Detailed morphology of Venus will be analyzed to compare Venus' evolutionary history with the Earth's.

The VRM system will consist of a spacecraft and scientific instruments. The major scientific instrument **will** be a synthetic aperture radar which will be used to map the surface of Venus. The VRM is basically a scaled-down version of the Venus Orbiting Imaging Radar Mission to allow a viable planetary program to be continued within budgetary constraints. For example, the VRM will be developed by making maximum use of existing designs, technology, and residual hardware. The spacecraft system will rely heavily on previous Voyager experience. The synthetic aperture radar (SAR) will be based on existing designs.

The VRM spacecraft will be launched by the Space Shuttle/Centaur in 1988 on a direct trajectory to Venus, and inserted into a 3.7-hour near-polar elliptical orbit. The VRM will map essentially the entire planet in 243 days.

During FY 1983, extensive definition and preparation activities will be conducted on the VRM mission definition and planning as part of the Planetary Exploration advanced programs activities.

The current planning estimate for the VRM mission is in the \$350 million range. This includes development through launch plus thirty days in-flight checkout, support during the 243-day mapping period, and analysis of the scientific data. The estimate for space transportation support is approximately \$155-165 million.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funds will be used to initiate design and development activities on the Venus Radar Mapper Mission. Full-scale development contracts for the spacecraft system and the synthetic aperture radar (SAR) instrument will be awarded. A systems requirement review will be held early in the year to assure that mission objectives are properly translated into system requirements. All system-level designs will be completed, and the system preliminary design review will be held at the end of the year. Emphasis will be placed on determining and specifying the SAR imaging quality parameters and the altimetry performance requirements based on input from the VRM scientists. The spacecraft preliminary design will be completed, radio and power subsystem procurements will be initiated, and procurement action will be initiated on structural and thermal materials. For the SAR, the detailed circuit design will be completed, the test circuits assembled, and certain long-lead electronic components will be ordered. A design concept for the mission operations systems will also be established.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

INTERNATIONAL SOLAR POLAR MISSION

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Spacecraft	---	---	---	3,000
Experiments	2,500	2,000	5,000	3,300
Ground operations	500	1,000	1,000	1,700
Auxiliary propulsion system.	<u>2,000</u>	<u>18,000</u>	<u>---</u>	<u>---</u>
Total.....	<u>5,000</u>	<u>21,000</u>	<u>6,000</u>	<u>8,000</u>
Space transportation systems operations	(7,300)	(12,600)	(9,400)	(35,200)

OBJECTIVES AND STATUS:

The International Solar Polar Mission (ISPM) is a joint NASA and European Space Agency (ESA) program wherein ESA will provide the spacecraft and some instrumentation and NASA will provide the remainder of the instrumentation, investigator support, launch services, tracking, and radioactive thermal power generations. The mission is designed to obtain the first view of the solar system from outside the plane in which the planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, thereby providing an insight into the effects of solar activity on the Earth's weather and climate. The ISPM will be launched in 1986 on the Shuttle/Centaur.

The ISPM was restructured in FY 1981, from a two-spacecraft mission--one provided by the United States and one provided by ESA--to a single ESA spacecraft mission; however, the United States participation in the program remains substantial. NASA is developing five of the nine principal investigator instruments and three of the four European investigations have U.S. co-investigators. In addition, the United States is providing two general purpose heat-source type radioisotope thermoelectric generators (RTG's); an adapter to accommodate the spacecraft integration with the Centaur; launch services; and tracking and data acquisition for the mission.

During FY 1983, the U.S. flight instruments will be delivered to the ESA spacecraft developer for integration and system testing. After the ISPM spacecraft system testing has been completed, the instruments will be calibrated before being stored in 1984 until launch. During FY 1983, the mission operations planning activities will be continued.

CHANGES FROM FY 1983 ESTIMATE:

The \$15.0 million dollar reduction in the ISPM FY 1983 estimate is the result of the change from an Inertial Upper Stage (IUS) launch to a Centaur Upper Stage. With the Centaur, there is no requirement for the development of a kick stage to accommodate integration with the spacecraft as there was with an IUS launch. There is, however, the requirement to develop an adapter to permit the ISPM spacecraft to be integrated with the Centaur.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding is required to complete development of the U.S.-developed equipment required to adapt the ISPM spacecraft with the Centaur upper stage. In addition, principal investigator support will be continued.

MISSION OPERATIONS AND DATA ANALYSIS

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Voyager extended mission.....	17,200	14,000	17,400	19,100
pioneer program.....	5,900	---	5,100	6,400
Planetary flight support.....	<u>19,500</u>	<u>12,500</u>	<u>16,000</u>	<u>17,900</u>
Total.....	<u>42,600</u>	<u>26,500</u>	<u>38,500</u>	<u>43,400</u>

OBJECTIVES AND STATUS:

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from the missions. Currently two major classes of planetary spacecraft are operating--the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetry and command functions for all planetary spacecraft.

Voyager 1 is now on a cruise trajectory which will take it out of the solar system at a steep angle to the plane of the ecliptic, and it will continue to collect data on the space environment as it proceeds to the outer limits of the solar system. Voyager-2 is now on a course that will allow it to encounter the planet Uranus in 1986.

Operation of the Pioneer Venus and the Pioneer 6-11 spacecraft is continuing. The Pioneer Venus orbiter continues to collect data on the planet Venus which is scientifically important and is very significant in preparing for the Venus Radar Mapper mission. The Pioneer 6-9 spacecraft are operating in interplanetary space in solar orbit, and data is being acquired from the spacecraft when unusual solar phenomena occur or as unique scientific opportunities arise. The Pioneer 10 and 11 spacecraft are on a course that will take them out of the solar system in opposite directions.

Analysis of data from these missions continues to reveal profound scientific results. Analysis of the Voyager-1 data has led to the discovery of an oxygen-bearing molecule in the atmosphere of Saturn's satellite Titan, forcing a significant revision in the Titan photochemical models. Operation of the Mutch Memorial Station (Viking Lander-1) on Mars provided recent dust storm observations and other meteorological data.

The planetary flight support activities are those tasks related to the unique nature of planetary spacecraft flight operations, including design, development and operations of the planetary navigation system, the ground command and control system, the image processing system, and the ground data handling systems. In addition, the planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory.

CHANGES FROM FY 1983 ESTIMATE:

The increase of \$12.0 million in the FY 1983 estimate is the result of Congressional appropriations above the FY 1983 request. This additional funding will be used to keep the Pioneer spacecraft operational, and to enhance the Voyager data collection and flight support preparations for the Voyager Uranus encounter.

BASIS OF FY 1984 ESTIMATE:

During FY 1984, the operation and data analysis activities for the Voyager and Pioneer spacecraft will be continued. The FY 1984 planetary flight support funding will provide for the continued development of systems necessary for the Galileo and ISPM missions, as well as preparations for the Voyager-2 encounter with Uranus.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>RESEARCH AND ANALYSIS</u>			
	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u> <u>Budget</u> <u>Estimate</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	
Supporting research and technology	35,200	28,500	37,600	34,500
Advanced programs.....	6,600	5,500	8,500	7,300
Mars data analysis	2,900	---	2,000	1,500
Halley's comet co-investigations and watch.....	<u>2,000</u>	<u>1,500</u>	<u>2,200</u>	<u>2,200</u>
Total.....	<u>46,700</u>	<u>35,500</u>	<u>50,300</u>	<u>45,500</u>

OBJECTIVES AND STATUS:

The research and analysis program consists of four elements required to: assure that data and samples returned from flight missions are fully exploited; undertake complementary laboratory and theoretical efforts; define science rationale and develop required technology to undertake future planetary missions; and coordinate an International Halley's Comet Watch and provide co-investigator support to the European Space Agency's Giotto mission to Halley's comet.

The supporting research and technology program element includes planetary astronomy, planetary geochemistry and geophysics, planetary atmospheres, planetary geology, planetary materials, and instrument definition.

The planetary astronomy activity includes all planetary observations made by ground-based telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high. The data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. The planetary astronomy funding in FY 1983 and FY 1984 provides for the continued operation of the Infrared Telescope Facility in Hawaii.

The planetary atmospheres activity includes data analysis, laboratory and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in a better understanding of our own weather and climate. Observations of the atmospheres of Venus, Jupiter and Saturn, acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in our knowledge about atmospheric sciences.

The planetary geochemistry and geophysics activity is broad in scope and includes studies of the composition and structure of all classes of solid body solar system objects. These investigations advance our understanding of the present state of the origin and evolution of the solar system. The program supports the synthesis of planetary data already obtained from previous missions, and the assembly of information needed to prepare for future missions. Both Voyager and Pioneer Venus continue to provide key data for these research efforts.

To date, the planetary geology activity has focused on studies of the surface properties of the inner planets (including the Moon). Voyager outer-planet data pertaining to the moons of Jupiter and Saturn, primarily ice-covered bodies, have provided a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting the development of surface features on bodies such as the inner planets provide a powerful technique for unravelling individual planetary histories. Imaging data, from both spacecraft and ground-based radar, provide the basis for much of the program.

The planetary materials activities support an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. The operation of the Lunar Curatorial Facility is also provided for within the planetary materials funding. This program is coordinated with the lunar sample and meteorite research supported by other agencies such as the National Science Foundation.

The instrument definition activity is directed toward ensuring that the science return from future missions is maximized through definition and development by the availability of state-of-the-art scientific instrumentation.

The objective of advanced programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated,

and their scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been studied by the Solar System Exploration Committee (SSEC), an advisory group, which has recommended several "low-cost" but scientifically important potential future missions.

The **Mars** Data Analysis efforts continue to assure that we capitalize on the wealth of data provided by Viking and earlier missions. This activity covers a broad scope of the analysis and synthesis of returned data related to the disciplines of biology, chemistry, geology, and meteorology.

The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985-1986 by supporting co-investigators on the European Space Agency (ESA) Giotto mission, and by conducting complementary remote sensing investigations using both Earth-orbiting and ground-based facilities. The ESA Giotto mission will fly by Halley's Comet in 1986. Concurrently, an observation program called the International Halley's Comet Watch, coordinated by the United States, will conduct world-wide scientific observations of the Comet Halley. The objectives of the Watch are to: (1) coordinate scientific observations of Comet Halley throughout its 1985-1986 apparition; (2) promote the use of standardized instrumentation and observing techniques; (3) help insure that data are properly documented and archived; and (4) receive and distribute data to participating scientists.

CHANGES FROM FY 1983 ESTIMATE:

The increase of \$14.8 million in the FY 1983 estimate is the result of Congressional appropriations over the FY 1983 budget request. These funds will be used to continue operation of both the Infrared Telescope Facility in Hawaii, and the Lunar Curatorial Facility at the Johnson Space Center. In addition, the university research program will be enhanced, the Mars data analysis activities will be continued, and the international Halley's comet watch activities will be enhanced.

BASIS OF FY 1984 ESTIMATE:

During FY 1984, research efforts will continue in the areas of planetary astronomy planetary atmospheres planetary geochemistry and geophysics, planetary geology, planetary materials, instrument definition, Mars data analysis, and development of required technology to undertake future missions. Telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetary atmospheres and in tenuous cometary atmospheres. In the geochemistry-geophysics area, research efforts will be carried out to better understand the present state of evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have

shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1984 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition for potential future missions will also be continued.

The FY 1984 Halley's Comet Co-Investigations and Watch funding is required to support U.S. co-investigators involved in the European Space Agency's Giotto mission. It is also required to provide support for a Jet Propulsion Laboratory management team who, together with several scientists at other institutions, are establishing a worldwide network for the astronomical study of Halley's Comet in 1985-1986.

SOLID EARTH
OBSERVATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

SOLID EARTH OBSERVATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of Dollars)	1983 <u>Current Estimate</u> (Thousands of Dollars)	1984 <u>Budget Estimate</u>	Page <u>Number</u>
Landsat-4.....	81,900	61,700	61,700	15,800	RD 6-4
Extended mission operations.....	2,800	1,800	1,800	1,000	RD 6-6
Shuttle/Spacelab payloads.....	12,300	13,800	13,800	15,000	RD 6-7
Geodynamics.....	22,900	26,200	26,200	28,000	RD 6-9
AgRISTARS.....	14,000	15,000	15,000	---	RD 6-12
Research and analysis.....	15,500	13,700	13,700	14,600	RD 6-13
Total.....	<u>149,400</u>	<u>132,200</u>	<u>132,200</u>	<u>74,400</u>	

Distribution of Program Amount by Installation:

Johnson Space Center.....	13,887	14,100	12,708	2,319
Kennedy Space Center.....	170	---	---	---
Marshall Space Flight Center.....	337	200	200	214
Goddard Space Flight Center.....	113,769	101,000	97,141	50,478
Jet Propulsion Laboratory.. ..	9,503	9,300	12,370	14,069
Ames Research Center.....	1,870	1,400	877	638
Langley Research Center.....	50	---	---	---
National Space Technology Laboratories	3,414	2,600	2,144	1,081
Headquarters.....	6,400	3,600	6,760	5,601
Total.....	<u>149,400</u>	<u>132,200</u>	<u>132,200</u>	<u>74,400</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

SOLID EARTH OBSERVATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Solid Earth Observations program are to develop and apply space observation techniques to meet national and global needs for improved management of food, fiber, water and land resources; to improve our ability to systematically evaluate the composition and geometry of the Earth's mineral and energy resources; and to increase our understanding of the Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and mechanisms associated with the occurrence of earthquakes.

Principal elements of the program include the development of space and supporting ground systems and improved data processing and analysis techniques; Shuttle and aircraft support for sensor and technique development; as well as basic and applied research for identifying, monitoring, analyzing and modeling the vegetated and geological features of the Earth.

Another aspect of the Solid Earth Observations program is the research associated with understanding the physical relationship of sensed phenomena to various types of vegetation and other surface features with the radiation which they emit or reflect; the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. These activities include individual scientific studies and projects, such as the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS).

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information which is needed to: understand the processes leading to the release of crustal strain in the form of earthquakes; improve our understanding of the formation of mineral deposits; contribute to long-term weather and climate forecasting; and better understand the Earth as a planet. Space techniques such as laser ranging to satellites and the Moon, and very long baseline interferometry using radio stars or satellites, are the only methods which can provide the precise measurements needed for these studies.

Landsat-4 was launched in July 1982 and both the flight and ground systems are performing well. Data from the two key instruments, the Thematic Mapper (TM) and the Multispectral Scanner (MSS), are proving to be

very useful to the science and applications community. The TM data received and processed to date is of excellent quality and holds promise for many new applications in civil remote sensing. NOAA will assume operational responsibility in 1983 for the spacecraft and MSS instrument, while NASA will operate and conduct research with the TM experiment until 1985. Development of the Landsat-4 backup spacecraft, Landsat-D prime, will be completed in 1983 and turned over to NOAA for storage.

The objective of the Shuttle/Spacelab payload development project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid earth observations research. Both the Shuttle Imaging Radar, which was flown on the Shuttle orbital test flight in November 1981 to evaluate the utility of spaceborne imaging radar for geologic exploration, and the Shuttle Multispectral Infrared Radiometer, which was used to determine the optimum spectral bands for surface materials classification, operated successfully. The Large Format Camera, required for high resolution mapping applications, is being prepared for launch on the Shuttle in 1984. The next generation Shuttle Imaging Radar is under development leading to a 1984 Shuttle launch.

The focus of the Multispectral Linear Array (MLA) advanced technology development is on the development of a future high performance MLA instrument which can be used as a diagnostic tool for fundamental research in remote sensing. The MLA solid-state sensor has a number of significant features such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research on the linear array instrument and the Shuttle Imaging Spectrometer is being continued in FY 1983.

BASIS OF FY 1984 FUNDING REQUIREMENTS:LANDSAT-4

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	<u>1984</u> Budget <u>Estimate</u>
Spacecraft systems and sensors.....	50,400	19,800	19,800	1,300
Ground systems.....	20,600	28,300	28,300	2,500
Ground operations.....	8,000	10,400	10,400	9,600
Investigations.....	<u>2,900</u>	<u>3,200</u>	<u>3,200</u>	<u>2,400</u>
Total.....	<u>81,900</u>	<u>61,700</u>	<u>61,700</u>	<u>15,800</u>
Delta (expendable launch vehicles program).....	(6,300)	(3,000)	(6,300)	(2,600)

OBJECTIVES AND STATUS:

The objective of the Landsat-4 program is to develop, launch, and operate an advanced land observing system and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental Thematic Mapper (TM) and the flight-proven Multispectral Scanner (MSS). Landsat-4 was launched successfully in July 1982. The Landsat-4 backup spacecraft (Landsat-D prime) will be available for launch in 1983. The major technical focus of the Landsat-4 program involves a test of the Thematic Mapper's capabilities and an improved ground data handling system. The Thematic Mapper will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of Landsat data and enhance many current uses.

Landsat-4 is operating satisfactorily. While the National Oceanic and Atmospheric Administration (NOAA) will assume control of Landsat-4 operations in early 1983, NASA will maintain operation of the TM and associated systems. The completion of Landsat-D prime is scheduled for 1983; NOAA will store the spacecraft until it is required for launch.

The Thematic Mapper (TM) processing system is nearing completion. At the time of the Landsat-4 launch, the TM research and development data production rate was approximately one scene per day. During the first year of operation, the sensor performance is being characterized and the necessary software is being developed to permit a production rate of 12 scenes/day by mid-1983, rising to 50 scenes a day upon turnover of the TM system to **NOAA** for routine operations.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funds will be used to operate the Landsat TM data processing ground systems, and to complete **NASA's** engineering characterization of the TM data.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

EXTENDED MISSION OPERATIONS

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1983 <u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Landsat-2 and -3.....	2,575	1,700	1,700	1,000
Magsat.....	<u>225</u>	<u>100</u>	<u>100</u>	<u>---</u>
Total.....	<u>2,800</u>	<u>1,800</u>	<u>1,800</u>	<u>1,000</u>

1 AND STATUS:

The objective of extended mission operations is to capitalize on the continued performance of Solid Earth Observations program satellites beyond the initial planned mission duration. Data products from these missions are being used to support research and operational activities in agriculture, water resources, geology, and land use. In the case of Landsat, some operational requirements of federal and state agencies, plus many private interests are now being satisfied.

Landsat-3 is currently operating and providing data, although at reduced operational levels. Completion of Magsat data analysis will be accomplished in 1983.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding is required to support the analysis of data as it applies to agricultural, forestry, water, and land management studies. Landsat-3 will be maintained in a standby operational mode through FY 1984.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

	<u>1982</u>	<u>1983</u>		<u>1984</u>
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Payload development.....	3,600	1,500	2,000	5,000
Large format camera.....	1,700	1,300	1,300	700
Multispectral linear array.....	<u>7,000</u>	<u>11,000</u>	<u>10,500</u>	<u>9,300</u>
Total.....	<u>12,300</u>	<u>13,800</u>	<u>13,800</u>	<u>15,000</u>

OBJECTIVES AND STATUS:

The objective of this project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research.

In FY 1983, preparations are continuing for the flights of the Large Format Camera (LFC) and the Shuttle Imaging Radar-B (SIR-B). The Large Format Camera is required for high resolution mapping applications. The new attitude reference system for the LFC has been completed, and the launch of the LFC is scheduled for 1984. The SIR-B will obtain a quantitative assessment of the effect of various radar viewing geometries on the mapping of surface texture and topographic features. The SIR-B instrumentation is based on an upgraded SIR-A instrument including the addition of a variable look angle antenna, digital data handling, and increased bandwidth and resolution. Data will be recorded on board and transmitted via the Tracking and Data Relay Satellite System (TDRSS).

The focus of the Multispectral Linear Array (MLA) technology development is on a future high performance MLA instrument for use as a diagnostic tool on the Space Shuttle for fundamental research in remote sensing. The MLA class of solid state sensors has a number of significant features, such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The MLA will be flown and tested on a future Shuttle/Spacelab mission.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The FY 1983 estimate remains unchanged in total, although the payload development estimate was increased by \$500,000 to accelerate the flight of SIR-B to 1984. A corresponding minor reduction was made in the funding.

BASIS FOR FY 1984 ESTIMATE:

FY 1984 funding is required for experiment operations and data analysis for two flights of the Large Format Camera and the first flight of the Shuttle Imaging Radar-B (SIR-B). FY 1984 funding is also required for continued definition of a Multispectral Linear Array Shuttle mission concept and development of an MLA experimental instrument.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**GEODYNAMICS**

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Crustal dynamics project	14,000	16,500	16,500	17,500
Laser network operations.....	6,900	7,000	7,000	7,500
Research and technique development....	<u>2,000</u>	<u>2,700</u>	<u>2,700</u>	<u>3,000</u>
Total.....	<u>22,900</u>	<u>26,200</u>	<u>26,200</u>	<u>28,000</u>

OBJECTIVES AND STATUS:

The Geodynamics program makes use of the unique capabilities provided by space techniques to improve our understanding of the dynamic processes occurring within the Earth and at its surface. The objectives of the program are to: contribute to studies of earthquake mechanisms by measuring and modeling crustal deformation at active plate boundaries; verify and extend tectonophysical theories by measuring the contemporary motions of the plates and determining the plate-driving forces; study causative relationships between variations in the Earth's polar motion and rotational rate with earthquake occurrence, internal core dynamics, and other physical phenomena; model geophysical processes associated with the formation of petroleum and mineral deposits; study mantle convection and the internal composition and structure of the Earth; and facilitate the establishment of new geodynamic measurement services which will make use of precise position determination methods.

The principal activity under the Geodynamics program is the crustal dynamics project. This project supports the development of laser ranging and very long baseline interferometry systems for measurement of plate motion, plate stability, regional crustal deformation, polar motion, and Earth rotation. The data obtained is expected to contribute to the understanding of why and how earthquakes occur and, perhaps, to the development of earthquake prediction methods. Project activity is conducted jointly with the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the National Science Foundation, and the Defense Mapping Agency, through an interagency agreement for the application of space technology to crustal

dynamics and earthquake research. The laser network supports the project through the acquisition and processing of laser data for sites in the United States, the Pacific, South America, and Australia.

A principal focus of the crustal dynamics measurements has been the study of the relative motion of the North American and Pacific plates at their boundary along the San Andreas fault system in California, and of how and where crustal strain is accumulating in this area. In 1982 an agreement was concluded with Mexico for a U.S. laser ranging site at Mazatlan. With this new location, it will now be possible to study the continuation of the San Andreas fault into the Gulf of California, and the spreading of Baja California northward away from the mainland. In 1984, measurements of crustal deformation in the western United States and northern Mexico will be continued, and will be extended into Canada; measurements in Alaska will be started. Since major earthquakes are infrequent in the United States, NASA is cooperating with a consortium of European countries in studies of regional crustal deformation in the eastern Mediterranean. These studies will begin in 1984 through the use of U.S. systems and systems developed by the Europeans.

To date, measurements of present plate motion have been limited to the Pacific, Australian, North American, and Eurasian plates. In 1982, agreements were concluded with France for a laser ranging site in the Society Islands, and with Chile for a laser site on Easter Island. In addition, the Japanese have procured a laser from a U.S. source and, based on an earlier agreement with NASA, are developing a microwave interferometry system. In 1983, the Easter Island laser will be used to start measurement of the movement of the Nazca plate relative to the South American plate, and in 1984 extensive studies of the movement and internal deformation of the Pacific plate will be studied using sites in Japan, Alaska, Hawaii, the Society Islands, and Australia.

Development is continuing on a geodetic receiver design (SERIES), which uses signals from the Global Positioning System. The mobile laser stations (MOBLAS) have been upgraded to two-centimeter ranging, and two highly mobile transportable laser stations (TLRS) have been completed and deployed. An interagency plan has been initiated to establish the national crustal motion network by NOAA in 1984 with NASA assistance, to operate a polar motion monitoring network (POLARIS) by NOAA, and to establish local crustal strain monitoring networks by U.S. Geological Survey through the use of Global Positioning System receivers. The feasibility of using satellite-to-satellite tracking to substantially improve gravity field surveys was demonstrated in the laboratory. Conceptual studies of the Geopotential Research Mission, aimed at making the next major advance in gravity and magnetic field measurement, have been completed.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the western United States regional deformation measurements and measurements of the relative motion of the North American and Pacific plates will be continued. Analysis of these data and earlier data will provide maps of large-scale crustal deformation in the western United States. Alaska regional measurements will be initiated. Operation of the laser network will be continued. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling and interpretation of geopotential fields will be continued. System definition studies for the Geopotential Research Mission will be conducted.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>AGRISTARS</u>			
	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Technique development.....	1,700	2,800	2,800	---
Supporting research.....	7,400	7,400	7,400	---
Early warning, soil moisture, domestic crop and land cover, and conservation.....	<u>4,900</u>	<u>4,800</u>	<u>4,800</u>	---
Total.....	<u>14,000</u>	<u>15,000</u>	<u>15,000</u>	<u>---</u>

OBJECTIVES AND STATUS:

AgRISTARS is a research, development and test program, which addresses Department of Agriculture (USDA) information requirements by combining NASA's unique remote sensing research and development with complementary resources from the USDA and Department of Commerce. Improved information on world agricultural production has been identified by the USDA as a major information requirement for establishing effective United States agricultural policies, and for efficient operation of United States agricultural markets. With present resource limitations and political situations in many countries, aerospace remote sensing provides the only feasible means for making reliable foreign production forecasts.

This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. In addition to commodity production forecasting improvement, USDA information requirements are in the areas of resource management, land-use monitoring, and the remote measurement of soil moisture. NASA AgRISTARS efforts will be terminated in FY 1983, but AgRISTARS-type research and development will be continued by other agencies.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS (SOLID EARTH OBSERVATIONS)

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Fundamental research.....	1,500	2,800	2,800	3,500
Renewable resources.....	3,500	3,400	3,400	3,200
Nonrenewable resources.....	4,300	6,500	6,500	7,100
Advanced studies.....	1,200	1,000	1,000	800
Technology transfer.....	<u>5,000</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.....	<u>15,500</u>	<u>13,700</u>	<u>13,700</u>	<u>14,600</u>

OBJECTIVES AND STATUS:

The goals of the research and analysis activities are: to improve our understanding of the remote sensing process; to develop remote sensing techniques that aid in the management of renewable and nonrenewable resources, to monitor the impact of man on the natural environment, and to perform feasibility studies required prior to initiation of new space flight sensor development and mission definition. This program incorporates the field experiments with aircraft and satellite-based data analysis for renewable and nonrenewable solid Earth observations research, and associated feasibility and conceptual design studies of future sensors, Shuttle experiments, and space missions.

The overall objectives of this effort are: to improve techniques for machine-aided Earth resource information extraction from space-derived data; to analyze science requirements for new types of space acquired data; to develop and test ground-based or airborne systems that are derived from space technology; to perform feasibility, conceptual design, and detailed systems definition studies of new sensors and missions; and to perform feasibility and conceptual design studies of new sensors and missions.

In fundamental research, a coordinated set of theoretical and experimental investigations is being continued in scene radiation, atmospheric effects characterization, mathematical pattern recognition, and

image analysis. This research extends and strengthens our basic understanding and provides the generic remote sensing science required for technique development in the renewable and nonrenewable resource discipline sciences.

In renewable resources, the focus is on evaluating the improved capability of the Landsat-4 Thematic Mapper over the Multispectral Scanner to inventory and determine contributing sensor parameters and to monitor land cover. The Thematic Mapper data analysis has confirmed our findings from simulator research regarding increased dimensions of the data over Multispectral Scanner and a continuing as well as increased level of information. Multisensor and multispectral research is being conducted to extend this technique from the visible infrared to the microwave regime in a synergistic way.

The objectives of the nonrenewable resources effort are to: develop techniques for extracting useful geological information from remote sensing measurements; employ remote sensing techniques in unique and innovative ways for studies of crustal geology; develop improved geological models which can make effective use of unique types of information derived from space-acquired data; and experimentally evaluate the utility of remote sensing methods for specific geological applications. Emphasis has been placed on the use of thermal infrared and microwave remote sensing techniques. Development of an infrared aircraft scanner was completed and flown during 1982 to collect six-channel multispectral data in the 8-13 micron spectral region over a series of western United States test sites. In addition, intensive analysis and interpretation of the radar imaging data obtained during the second Shuttle orbital test flight is being continued in FY 1983.

In the advanced studies area, feasibility and conceptual design studies of future sensors and missions are being conducted to ensure the conceptualization of high priority future capabilities in remote sensing of Earth resources.

BASIS OF FY 1984 ESTIMATE:

During FY 1984, the research and analysis disciplines will make use of the data from the infusion of Landsat-4 Thematic Mapper data. New radar data from the SIR-B will also become available. The FY 1984 Research and Analysis program will focus on the analysis of these new data and technique development will be continued with emphasis on merging multisensor/multispectral data sets. Advanced mission studies will be continued with emphasis on Shuttle-borne sensor feasibility studies and space station payload studies.

ENVIRONMENTAL
OBSERVATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

ENVIRONMENTAL OBSERVATIONS PROGRAM

SUMMARY OF RESOURCE REQUIREMEN

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>	Page <u>Number</u>
Upper atmosphere research and analysis.	20,500	27,700	27,700	29,600	RD 7-6
Atmospheric dynamics and radiation research and analysis	22,300	26,500	26,500	28,400	RD 7-8
Oceanic processes research and analysis	16,900	17,000	17,000	18,200	RD 7-10
space physics/ATD research and analysis	12,123	15,200	15,200	15,700	RD 7-12
Shuttle/Spacelab payload development...	4,100	3,700	3,700	7,600	RD 7-14
Operational satellite improvement program.....	6,000	6,000	6,000	600	RD 7-17
Earth radiation budget experiment	24,000	24,000	24,000	15,500	RD 7-18
Extended mission operations	16,100	22,400	22,800	27,400	RD 7-20
Upper atmosphere research satellite experiments and mission definition.....	6,000	14,000	14,000	20,000	RD 7-23
Halogen occultation experiment	5,000	---	---	---	
Total.....	<u>133,023</u>	<u>156,500</u>	<u>156,900</u>	<u>163,000</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of	Dollars)	
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center.....	147	170	170	170
Marshall Space Flight Center.....	5,348	5,860	5,860	6,830
Goddard Space Flight Center.....	80,281	95,682	96,082	93,939
Jet Propulsion Laboratory.. ..	18,450	22,477	22,477	24,091
Ames Research Center.....	2,640	3,388	3,388	3,614
Langley Research Center.....	9,571	8,707	8,707	8,716
Lewis Research Center.....	100	---	---	
Headquarters	<u>16,486</u>	<u>20,216</u>	<u>20,216</u>	<u>25,640</u>
<u>Total.....</u>	<u>133,023</u>	<u>156,500</u>	<u>156,900</u>	<u>163,000</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

ENVIRONMENTAL OBSERVATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Environmental Observations program are to improve our understanding of the processes in the atmosphere and the oceans, provide space observations of parameters involved in these processes, and extend the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes solely, observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical and dynamic processes occurring in the atmosphere and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimization of the use of space-derived measurements in understanding large scale weather patterns; advances in our knowledge of severe storms and forecasting capabilities; ocean productivity and air-sea interactions; and an improved knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction and a comprehensive understanding of the solar terrestrial connection and detailed determination of the physics and coupling between the solar wind, magnetosphere, and ionosphere.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation, laboratory research of fundamental processes, development of instrumentation, flight of the instruments on the Space Shuttle and dedicated spacecraft, collection of ~~in situ~~ ancillary or validation data, and scientific analysis of data. The approach is to develop a technological capability and a strong scientific base and then to collect appropriate data (from space and ~~in situ~~) which, taken together, will address a particular program objective.

Studies of the upper atmosphere have led to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone which was reported to the Congress in January 1982. The revised assessment of the

predicted impact is somewhat less severe; this assessment is the result of improved measurements in our continuing program of laboratory chemical kinetics measurements.

Three-dimensional models of the stratosphere are being developed to quantify our understanding of the interrelation of chemistry with dynamics and radiation. The record of satellite ozone measurements now extends for over a decade and is being used in studies to determine if there have been long term trends in the average amount of global ozone which shields the Earth's surface from harmful ultraviolet radiation.

The Upper Atmospheric Research Satellite Experiments (UARSE) development effort which was initiated in FY 1982 will provide a set of satellite instruments capable of making a comprehensive measurement of the state of the stratosphere. Detailed definition studies of sixteen instruments have been completed, and an instrument complement has been selected. Further definition of the UARS mission will be undertaken to **try** to decrease the cost of the mission below the current estimate.

The Earth Radiation Budget Experiment (ERBE) development is proceeding on schedule toward a 1984 launch date. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOAA) by managing the implementation of the NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis. Preparations are proceeding to launch NOAA-E and GOES-F in 1983, and NOAA-F in 1984.

The ability to perform temperature and moisture soundings of the atmosphere from geostationary orbit has been demonstrated by the flight of the NASA-developed visible/infrared spin-scan radiometer and atmospheric sounder instrument on GOES-4 and NOAA-5 spacecraft. The opportunity afforded by geostationary orbits to observe a localized region continuously will permit intensive study of the evolving temperature and moisture environment of severe local storms. Low Earth orbit sounding capabilities are now enabling the extension of forecast reliability from three to five days. In certain situations, reliable forecasts of **8** to 10 days duration have been achieved.

Virtually all of the data from the Seasat mission has been archived and much of the Nimbus-7 ocean data has been analyzed. This information is being used to define potential low cost approaches to use demonstrated ocean observing techniques to address a variety of ocean research challenges.

The Nimbus spacecraft continue to collect unique data sets to aid in the study of long term trends of the Earth's atmosphere, oceans and polar ice. The Solar Mesosphere Explorer (SME) data collection over the last year has made a major contribution to the study of the El Chichon volcano. In addition, the ISEE-3 spacecraft will be prepared for the planned encounter with the comet Giacobini-zinner in 1985.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:**UPPER ATMOSPHERE RESEARCH AND ANALYSIS**

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Upper atmospheric research.....	12,900	16,500	16,500	17,650
Stratospheric air quality research....	4,400	6,000	6,000	6,400
Tropospheric air quality research.....	<u>3,200</u>	<u>5,200</u>	<u>5,200</u>	<u>5,550</u>
Total.....	<u>20,500</u>	<u>27,700</u>	<u>27,700</u>	<u>29,600</u>

OBJECTIVES AND STATUS:

The upper atmospheric research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change.

In particular, the goal of the upper atmospheric research program is to understand the physics, chemistry and transport processes in the atmosphere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities. In order to accomplish this, efforts are underway to: (1) improve upper atmosphere and global troposphere models, validate them, and assess their uncertainties; (2) measure important trace chemical constituents, temperature, and radiation fields throughout the atmosphere; (3) develop sensors capable of making chemical and physical measurements of the upper atmosphere and the global troposphere in situ and remotely from space; (4) assemble and maintain the existing long-term data base of stratospheric and tropospheric ozone measurements to aid in the detection of long-timescale natural variations and man-made ozone changes; (5) determine the effects of global tropospheric chemistry on the atmosphere as a whole in order to assess the role of the global troposphere as the source and sink of stratospheric species; and (6) conduct theoretical and field studies of **tropospheric/stratopheric** exchange; and (7) carry out laboratory kinetics and spectroscopy to support these activities.

A wide variety of ~~in situ~~ and remote sensing instruments needed to meet the objectives of determining and understanding the distribution of ozone and key nitrogen, hydrogen, and chlorine radical and molecular species in the atmosphere have been developed and utilized. These measurements have been made from the ground as well as from aircraft, balloons, rockets, and spacecraft. A number of advanced measurement systems are being developed and will be test-flown on the Shuttle in order to explore the unique Shuttle capabilities for environmental sensing. With the recent availability of processed data from the Stratospheric Aerosol Gas Experiment (SAGE), Nimbus-4, -6, -7, and the Defense Meteorological Satellite, a major effort is underway to extract the maximum understanding from this data. An Applications Notice has been released specifically to encourage a broad range of additional scientific investigations with this unique data.

BASIS FOR FY 1984 ESTIMATE:

During FY 1984, the assessment and evaluation of human and natural perturbations on the stratospheric ozone layer and the atmospheric chemistry and dynamics that drive those perturbations will be continued. The development of one, two, and three dimensional models which couple radiative, dynamic and chemical processes will be continued; as will investigations and measurements of atmospheric trace chemical species and atmospheric winds throughout the atmosphere. **Also**, the global tropospheric ozone concentration distribution and the factors that control it will continue to be studied. In addition, there will be continued emphasis on the analysis of satellite data sets (Nimbus-6, -7 and Solar Mesosphere Explorer), as well as a modest expansion of research into the mesosphere.

The balloon program will be continued at a level of approximately 30-45 flights during 1984. These balloon flights provide the principal capability to validate the stratospheric photochemistry program. Balloon flights also provide for instrument calibration and intercomparisons of different measurement techniques. Aircraft will provide the major means for studying the global troposphere and tropospheric/stratospheric interchange. Studies of potential development instruments will maintain progress toward the development of spaceborne active and passive measurement capabilities which is required to provide global data on trace species.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

ATMOSPHERIC DYNAMICS AND RADIATION RESEARCH AND ANALYSIS

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	<u>1984</u> Budget <u>Estimate</u>
Research and analysis	22,300	26,500	26,500	28,400

OBJECTIVES AND STATUS:

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program includes Global Weather, Severe Storms and Local Weather and Climate research. These research activities involve large-scale atmospheric processes, general circulation, atmospheric-surface interactions, mesoscale processes including severe weather phenomena, and radiation balance studies in order to further man's understanding of the atmosphere on all temporal and spatial scales and to study the capability for measuring these processes from space.

The research and analysis program objectives are to: define and develop techniques for advanced remote sensing; develop algorithms to analyze the remotely sensed observations for purposes of validation and diagnostic studies; model the behavior of the atmosphere on a wide range of temporal and spatial scales; and simulate the capabilities of new remote sensors in order to assess their performance prior to developing actual hardware. These activities consist of an integrated program of research, technology development, environmental measurement, and interpretation. Concepts for advanced sensors are being developed, breadboard instruments are being fabricated for demonstration and assessment, and advanced studies are being conducted to define new systems and missions.

NASA continues to conduct definition studies of remote sensors to measure wind, temperature, pressure and moisture profiles with improved resolution and accuracy. Full exploitation of data from advanced sensors which are now used operationally by NOAA is being pursued. New techniques to improve the quality of data by removing cloud and moisture contamination will permit the sea and land surface temperature data to be collected with accuracy. Studies of the impact of satellite sounding data on our ability to define the

state of the global atmosphere continue to substantiate the value of such data to large-scale predictability. The data sets from the Global Weather Experiment are continuing to provide new insight into the nature and behavior of general circulation. The eruptions of Mt. Saint Helens and El Chichon have created unique opportunities in terms of measuring the effects of significant increases in atmospheric aerosol content on the climate and providing unique information on transport processes in the stratosphere. The advanced high speed vector processor has completed acceptance testing and will become operational during FY 1983. This processor will vastly improve our ability to process data faster, to run new and more sophisticated models, and to conduct important numerical studies that were formerly impossible to perform.

BASIS FOR FY 1984 ESTIMATE:

During FY 1984, research on atmospheric problems through the use of spaceborne techniques will be continued. In addition, FY 1984 funding is required for: processing space data to obtain useful atmospheric information, developing models which can utilize the advantages of satellite observations, assessing the value of space observations in modeling, and assessing space observing systems through simulation studies. Improved instrument concepts will be tested in the laboratory, or aboard balloons and aircraft. A major effort to collect and process cloud data from the five geostationary and two polar orbiting satellites will be continued during FY 1984 as part of the International Cloud Climatology Project study. Development of active temperature, pressure, and moisture sounders will also be continued during FY 1984. An airborne Doppler lidar system, which will be capable of measuring winds in clear air, will be flown around storm systems to measure the details of their dynamics during FY 1984. In addition, complex models of the storm scale will be run for evaluation, and expanded general circulation models, including up to 25 vertical levels, will be developed and tested.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

OCEANIC PROCESSES RESEARCH AND ANALYSIS

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Research and analysis.....	16,900	17,000	17,000	18,200

OBJECTIVES AND STATUS:

The goal of the Oceanic Processes program is to develop and apply spaceborne techniques to advance our understanding of the fundamental behavior of the oceans. The primary objectives are to: process data from past and existing spacecraft (Seasat and Nimbus-7); to make these data available to the community in usable and workable form; assess the performance of sensors to obtain useful geophysical information; and use this information for scientific analysis. All Seasat data have been archived at NOAA in a centralized data storage facility, and interactive computer terminals have been installed at five oceanographic research centers. Procedures have been implemented to allow routine processing of Nimbus-7 data without any backlogs.

The capability of existing technology to measure oceanographic variables within acceptable limits of accuracy has already been demonstrated. Subsequently, efforts have been focused on scientific analysis of the geophysical data generated by these sensors. In the past year the first global data sets for ocean surface winds have been produced from Seasat scatterometer data, and for ocean wave height from altimeter data. Support of science working groups is being continued to identify science questions addressable by technological capability, to determine observational requirements, and to better define performance specifications for future sensors. Reports by the altimeter, scatterometer, and sea-ice Science Working Groups have recently been published, and a report by the Ocean Color Science Working Group will be published soon.

BASIS FOR FY 1984 ESTIMATE:

During FY 1984, Nimbus-7 data collection and processing will be continued, and several Science Working Group studies will be completed. Seasat science analysis will also be continued during FY 1984.

Work will be continued on the Pilot Ocean Data System implementation, with a major thrust to formulate plans for expansion, to utilize the system to support a sea surface temperature workshop, to archive Nimbus-7 coastal zone color scanner data, and to establish a coastal zone color scanner/sea surface temperature time series during FY 1984. Definition and refinement of in situ sensors are currently underway and will be continued during FY 1984. These sensors are necessary to reveal the three-dimensional structure of the ocean, as satellite platform observations are limited to the sea surface.

FY 1984 funds are also required to define an observational capability utilizing existing technology to advance our understanding of fundamental ocean behavior. For example, definition of the Ocean Topography Experiment (TOPEX), which will require a dedicated mission employing an altimeter to acquire information on global ocean circulation, will be continued during FY 1984. Piggyback deployment of sensors on satellites sponsored by other government agencies will also be conceptualized in FY 1984, such as a scatterometer on a proposed DOD mission, and an Ocean Color Imager on NOAA's series of meteorological satellites. In addition, discussions will be held with other agencies and foreign governments regarding the possibility of receiving data from their sensors. Some examples of possibilities are the United States Air Force's microwave radiometer and ESA's SAR are possibilities for conducting ice research. Spaceborne sensors provide the only existing means for obtaining systematic global observations, which are essential for understanding ocean behavior, and the effects of such behavior on climate and terrestrial processes.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

SPACE PHYSICS RESEARCH AND ANALYSIS

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Plasma physics SR&T and data analysis	9,251	12,324	12,324	12,600
Solar terrestrial theory.. .. .	<u>2,872</u>	<u>2,876</u>	<u>2,876</u>	<u>3,100</u>
Total.....	<u>12,123</u>	<u>15,200</u>	<u>15,200</u>	<u>15,700</u>

OBJECTIVES AND STATUS:

The space physics research and analysis program is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in space and in the vicinity of the Earth and other planets. These studies include: the complex coupling of the atmosphere with the ionosphere and the magnetosphere; the solar wind and how it interacts with planetary magnetospheres and ionospheres; and, how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere. The discipline also includes the use of space as a laboratory for the study of plasmas in regimes that are unattainable on the Earth. The understanding of the plasmas in the solar system, the only naturally occurring plasmas to which we have direct access, will enable us to refine theories regarding astrophysical plasmas.

The major thrust of the space physics program is directed at studies of the near Earth environment, from the flow of solar wind past the magnetosphere, to manifestations of variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest, but there is often a practical component concerned with these aspects such as ionospheric influences on communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

The present state of the field is one of relative maturity, with an emphasis on multipoint and time sequence measurements and active perturbation experiments rather than isolated exploratory observations. For example, there are presently three spacecraft, the International Sun-Earth Explorer (ISEE) and the two Dynamics Explorer spacecraft, taking such measurements. In addition, the Active Magnetospheric Particle Tracer Explorer (AMPTE), which is scheduled for launch in 1984, will be making time sequence measurements. There is an active program of sounding rocket and balloon investigations aimed principally at spatially or temporally isolated ionospheric or magnetospheric phenomena such as aurora or equatorial ionospheric disturbances. An active theoretical and modeling program and a small supporting laboratory program are also being conducted.

The solar terrestrial theory program continues to provide a strong basis for all of the programs in both solar physics and space plasma physics. Theoretical groups are engaged in research on virtually every aspect of the solar terrestrial problem by using both fundamental process calculations and numerical models of the large scale phenomena.

BASIS FOR THE FY 1984 ESTIMATE:

During FY 1984, NASA will continue its program of suborbital investigations, theoretical and laboratory studies, and analysis of existing data from spacecraft. Particular emphasis will be placed on the analysis of data from ISEE-3, which will spend most of 1983 in the Earth's magnetotail. It will then be redirected to encounter the comet Giacobini-Zinner in early 1984. Definition studies will be continued during FY 1984 for such missions as the Origin of Plasma in the Earth's Neighborhood (OPEN), dedicated Spacelab missions, and payloads for the future Tethered Satellite System.

The solar terrestrial theory program will be continued during FY 1984 to research the full range of phenomena in this portion of the environment. Steps will be initiated to build a comprehensive and quantitative aggregate model of the solar terrestrial interaction.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:**SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT (ENVIRONMENTAL OBSERVATIONS)**

	<u>1982</u>	<u>1983</u>		<u>1984</u>
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Measurement of air pollution from satellites (MAPS)	325	300	340	500
Atmosphere trace molecules observed by spectroscopy (ATMOS).....	2,327	2,100	2,100	2,000
Active cavity radiometer (ACR, ACRIM).	430	---	700	2,500
Light detection and ranging (LIDAR).	---	---	---	1,700
Principal investigator instrument development and reflight program.. ..	<u>1,018</u>	<u>1,300</u>	<u>560</u>	<u>900</u>
Total.....	<u>4,100</u>	<u>3,700</u>	<u>3,700</u>	<u>7,600</u>

OBJECTIVES AND STATUS:

The Space Transportation System offers the unique opportunity for frequent short-duration flight of instruments. The Environmental Observations program has incorporated this new capability in the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical.

The Measurement of Air Pollution from Satellites (MAPS) experiment set is a gas-filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on the Shuttle orbital flight test in November 1981. The instrument performed successfully and obtained approximately 40 hours of data on

the global distribution of carbon monoxide in the atmosphere. Data processing and validation is about 40 percent complete with the generation of global carbon monoxide maps pfr analysis. The MAPS experiment set has been approved for a reflight and has been assigned to the OSTA-3 payload, currently scheduled for launch in 1984.

The objective of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument delivery is scheduled for 1983 with a planned launch in 1984 on Spacelab-3.

In response to an Announcement of Opportunity, a number of principal investigator class instruments were selected for development and flight as part of the Shuttle/Spacelab payloads program. Payloads under development include Active Cavity Radiometer-I (ACR-I) which is designed to aid in the study of the Earth's climate and the physical behavior of the Sun. The instrument was delivered to the Kennedy Space Center in 1982 for flight on Spacelab-1 in 1983. A program for reflight of ACR-1 is being developed. Other experiments selected for reflight include certain instruments developed for flight on the Shuttle orbital flight tests, which will be reflown on Spacelabs -1, -2 and -3.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The FY 1983 budget estimate is unchanged in total; however, the redistribution of funds within the Shuttle/Spacelab Payloads Development line was required to provide for post-flight calibration and thermal vacuum activities for the MAPS instrument and the light detection and ranging (LIDAR) instrumentation. The principal investigator instrument development and reflight program funds were reduced somewhat to accommodate these requirements.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities, data reduction and refurbishment for reflight in 1984.

The initial flight of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) instrument is scheduled for 1984. The FY 1984 funding is required to support the continued science team activities.

FY 1984 funding is required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on a future Shuttle mission. Definition studies of a potential free-flyer version of ACR, which is called ACRIM, will also be undertaken. The principal investigator instrument development and reflight program will be continued in FY 1984 with research efforts concentrated on atmosphere chemistry, solar intensity and variability, and upper atmospheric winds.

During FY 1984, preliminary definition and breadboard laboratory activities will be conducted on the Light Detection and Ranging (LIDAR) instrumentation. Discussions are underway with the French regarding the possibility of this becoming a cooperative project.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:**OPERATIONAL, SATELLITE IMPROVEMENT PROGRAM (OSIP)**

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Improvement of operational satellite syste.....	6,000	6,000	6,000	600

OBJECTIVES AND STATUS:

The objectives of the operational satellite improvement program are to perform the research and development activities leading to definition of advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites. Current activities include the development of the solar backscatter ultraviolet (SBUV) instrument for monitoring of ozone fluctuations in the upper atmosphere; assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; and implementation of improvements to the high resolution infrared sounder (HIRS).

The Critical Design Review for the solar backscatter ultraviolet instrument was held in 1982. Delivery of the first unit for integration and launch on NOAA-F is planned for 1983. The design of the high resolution infrared sounder instrument improvements is in process and will be implemented in the units to be flown on NOAA-H, -I, and -J. The visible/infrared spin scan radiometer/atmospheric sounder investigations have shown that the instrument can detect and monitor meteorological conditions which are a precursor to severe storm development .

BASIS OF FY 1984 ESTIMATE:

In the future, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for defining and funding specific system improvements required for their operational missions. NASA will retain its role as system implementation agency for NOAA on a reimbursable basis when new or improved measurements or systems are required. The FY 1984 funding is required to phase out the NASA Operational Satellite Improvement program. These funds will provide for completion of the high resolution infrared sounder instruments and the solar backscatter ultraviolet instruments.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:**OPERATIONAL SATELLITE IMPROVEMENT PROGRAM (OSIP)**

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Improvement of operational satellite syste.....	6,000	6,000	6,000	600

OBJECTIVES AND STATUS:

The objectives of the operational satellite improvement program are to perform the research and development activities leading to definition of advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites. Current activities include the development of the solar backscatter ultraviolet (SBUV) instrument for monitoring of ozone fluctuations in the upper atmosphere; assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; and implementation of improvements to the high resolution infrared sounder (HIRS).

The Critical Design Review for the solar backscatter ultraviolet instrument was held in 1982. Delivery of the first unit for integration and launch on NOAA-F is planned for 1983. The design of the high resolution infrared sounder instrument improvements is in process and will be implemented in the units to be flown on NOAA-H, -I, and -J. The visible/infrared spin scan radiometer/atmospheric sounder investigations have shown that the instrument can detect and monitor meteorological conditions which are a precursor to severe storm development.

BASIS OF FY 1984 ESTIMATE:

In the future, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for defining and funding specific system improvements required for their operational missions. NASA will retain its role as system implementation agency for NOAA on a reimbursable basis when new or improved measurements or systems are required. The FY 1984 funding is required to phase out the NASA Operational Satellite Improvement program. These funds will provide for completion of the high resolution infrared sounder instruments and the solar backscatter ultraviolet instruments.

BASIS FOR FY 1982 FUNDING REQUIREMENTS:

EARTH RADIATION BUDGET EXPERIMENT

	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Spacecraft.....	11,330	15,100	13,000	4,700
sensors.....	10,565	4,900	7,200	2,650
Mission operations and data analysis..	<u>2,105</u>	<u>4,000</u>	<u>3,800</u>	<u>8,150</u>
Total.....	<u>24,000</u>	<u>24,000</u>	<u>24,000</u>	<u>15,500</u>

OBJECTIVES AND STATUS:

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insight into the reason for climatic fluctuations.

Experimental Earth radiation budget instruments have been flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. These studies also indicate the need for improved calibration of the sensors. Earth radiation budget measurements covering at least one full cycle of seasons are needed. In order to provide concurrent observations from one polar orbiting and one inclined orbit satellite, identical Earth radiation budget instruments will be installed on the NOAA-F and G satellites of the TIROS-N series, and on one dedicated NASA observatory at a mid-inclination orbit. The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

Development of the ERBE instruments is proceeding satisfactorily. The Critical Design Review was completed in June 1982. Delivery of the three ERBE instrument flight models is scheduled for 1983.

In addition to the ERBE instruments, the NASA observatory will carry the Stratospheric Aerosol and Gas Experiment (SAGE II). This instrument will provide aerosol measurement data. Both the preliminary and critical design reviews of the SAGE II instrument were completed in 1982. Delivery of the flight hardware is scheduled for 1983.

The Earth Radiation Budget Satellite (ERBS) critical design review was completed in early 1982. The ERBS observatory will be launched by the Shuttle to an altitude of 300km and will then be propelled to the operational altitude of 600km by an auxiliary onboard propulsion system. The planned launch dates for ERBS and for NOAA-F and G are scheduled for 1984 and 1986, respectively.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The FY 1983 budget estimate is unchanged in total; however, the redistribution of funds within the ERBE project was required to cover an increase in the cost of the instruments. Certain spacecraft and mission operations and data analysis activities have been rephased in accordance with the rescheduling of the launches.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding is required to complete the integration of the three ERBE flight instruments for the NOAA-F and G launches, plus the ERBS launch. The ERBS observatory integration with the ERBE and SAGE II instruments will be completed in 1984. Development of algorithms and simulation of data system operations will also be continued in FY 1984.

BASIS FOR FY 1982 FUNDING REQUIREMENTS:**EXTENDED MISSION OPERATIONS (ENVIRONMENTAL OBSERVATIONS)**

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>
Operations for the extended mission of:				
Nimbus-5, -6, and -7.....	9,935	8,200	8,200	8,000
Stratospheric aerosol and gas experiment (SAGE)	765	500	500	100
Solar mesosphere explorer (SME)	700	1,300	1,300	2,500
Solar backscatter ultraviolet instrument.....	---	---	---	900
International Sun-Earth explorers ...	3,800	2,600	3,000	5,650
Interplanetary monitoring platform..	700	500	500	650
Dynamics explorer	<u>200</u>	<u>9,300</u>	<u>9,300</u>	<u>9,600</u>
Total.....	<u>16,100</u>	<u>22,400</u>	<u>22,800</u>	<u>27,400</u>

OBJECTIVES AND US:

The objectives of the extended mission operations is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations. This currently includes nine spacecraft.

Launched in 1972, 1975 and 1978, respectively, the Nimbus-5, -6, and -7 spacecraft continue to provide significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, Ocean temperature and Ocean color. Preliminary evaluation of this data has demonstrated the utility of the measurements, and the instrument techniques are starting to be used on operational satellites. Reduction and validation of this data is continuing, as is the operation of the satellites themselves. There is a strong demand for historical and current data on radiation budget, atmospheric

dynamics, and trace constituent concentrations and distribution, as all of this data contributes to global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis, and Earth climate studies.

An important contributor to the ozone and aerosol data base is the Stratospheric Aerosol and Gas Experiment (SAGE) satellite which was launched in early 1979. The measurements by this satellite of the stratospheric aerosol loading from the Mt. Saint Helens volcano eruptions have contributed significantly to our overall understanding of natural perturbations to the stratosphere and the potential effect on weather and climate. The SAGE spacecraft subsequently experienced operational problems and was lost in April 1982. Data processing will be completed in FY 1984.

The Solar Mesosphere Explorer (SME), launched in October 1981, is providing major input into our overall atmospheric parameter data base. SME is making some of the simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere. Included in the data set are measurements of ozone, atomic oxygen, nitric oxide and temperature. The four ultraviolet instruments and the infrared instrument are functioning well. Early data results indicate greater short-term variations and magnitude than was expected of many of the atmospheric properties. SME also continues to make measurements of the El Chichon volcanic cloud. Not only is this data valuable to the understanding the short-term impact of volcanoes on the Earth's atmosphere, but it will provide data for use in the study of El Chichon's effect on the climate. A ground truth program to aid in the validation of the SME data is also being initiated. The International Ultraviolet Explorer (IUE) and International Sun-Earth Explorer (ISEE) continue to perform well, with very productive guest investigator programs.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$400,000 in the FY 1983 estimate is the result of Congressional appropriations above the FY 1983 request. This additional funding will be used to enhance International Sun-Earth Explorers data collection and analysis activities in support of the ISEE-3 encounter with the comet Giacobini-Zinner.

BASIS OF FY 1984 ESTIMATE:

FY 1984 funding is required to support mission operations and data analysis activities on the International Sun-Earth Explorer, the International Ultraviolet Explorer, and the Dynamics Explorer satellites. Processing and validation of data from Nimbus, SAGE, and SME satellites will also be continued in FY 1984 as will activities to provide ground truth data for a NASA-developed ozone instrument to be flown on a NOAA weather satellite. These satellites continue to produce an extremely valuable data on ozone

concentrations. This data will be used to estimate the occurrence of natural variations, sea surface temperatures, aerosol measurements, and ocean productivity. In addition, necessary correlative ground truth activity will be continued in FY 1984. These ~~in situ~~ observations are essential to verify the quality of remote observations and improve our ability to interpret them.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

UPPER ATMOSPHERE RESEARCH SATELLITE EXPERIMENTS (UARSE) AND MISSION DEFINITION

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	<u>1984</u> Budget <u>Estimate</u>
Upper atmosphere research satellite experiments and mission definition..	6,000	14,000	14 ,000	20 ,000

OBJECTIVES AND STATUS:

The Upper Atmosphere Research Satellite (UARS) mission is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. The UARSE program includes the design and development of the instruments necessary to accomplish the UARS mission and to further define such a mission. These instruments will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere. These measurements will complement the measurements of ozone and of atmospheric parameters affecting ozone that were made on Nimbus and SAGE. The UARS program is a critical element in NASA's overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics which will be required when very difficult decisions must be made in the future regarding production of chlorofluorocarbons. The UARSE instruments will also contribute to the assessment of the impact of stratospheric changes on our climate and will provide the data needed for a full understanding of the stratosphere. These understandings are essential for subsequent design and implementation of a long-term stratospheric monitoring activity.

A final selection of nine experiments has been made; however, further analysis is required to determine if the UARS mission can be conducted at a cost lower than is currently estimated. These nine experiments draw heavily upon the experience derived from earlier satellites. The experiment package includes infrared and microwave limb sounders requiring advances in cryogenics, solid-state devices and microwave antennas beyond the earlier capabilities. Final design and development of the selected instruments and instrument mounting module will proceed. A ground data handling facility, permitting near realtime interactive utilization of

data by the investigators is being studied as part of the UARSE activity, along with definition of the mission implementation concept. Mission implementation concepts will continue to be defined consistent with a balance of the measurement needs of the scientific program and alternative concepts of spacecraft requirements so that the cost of this mission can be minimized.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funds are required for continuation of the detailed design of the instruments, instrument module and observatory detailed design definition and analysis, detailed mission implementation studies, and definition of concept and design requirements for the ground data handling facility. The instruments are the long-lead time elements of the UARS program. Although there is considerable technological heritage for these instruments, their development and testing in time for a late 1980's launch opportunity requires that substantial progress in instrument design and in interface design i.e., thermal, mechanical, view angles, etc., with the instrument module take place in 1984.

The ground data handling facility will enable a high level of interaction among experimenters and between experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that it be designed early in the UARSE effort so that individual experiment data processing subsystems, including algorithms, and the interactive data base system can be designed for maximum interaction effectiveness.

MATERIALS
PROCESSING
IN SPACE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

MATERIALS PROCESSING IN SPACE PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of Dollars)	1983 <u>Current Estimate</u> (Thousands of Dollars)	1984 <u>Budget Estimate</u>	Page <u>Number</u>
Research and Analysis	12,000	13,100	13,100	14,000	RD 8-3
Materials Experiment Operations	<u>4,244</u>	<u>8,900</u>	<u>8,900</u>	<u>7,600</u>	RD 8-5
Total	<u>16,244</u>	<u>22,000</u>	<u>22,000</u>	<u>21,600</u>	
 <u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center	255	660	660	1,100	
Ames Research Center	180	---	---	---	
Marshall Space Flight Center	8,375	8,889	8,889	7,200	
Lewis Research Center	540	1,261	1,261	1,650	
Langley Research Center	20	310	310	400	
Jet Propulsion Laboratory.. ..	4,509	4,220	4,220	5,200	
Headquarters	<u>2,365</u>	<u>6,660</u>	<u>6,660</u>	<u>6,050</u>	
Total	<u>16,244</u>	<u>22,000</u>	<u>22,000</u>	<u>21,600</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

MATERIALS PROCESSING IN SPACE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1983 are being concentrated on four major processing areas: crystal growth and solidification, containerless processing, bioseparation processes, and fluid and chemical processing. Limited research will be supported in the areas of cloud physics, combustion science, and fluid dynamics. These activities will provide the scientific basis for future space applications of materials processing technology. Definition studies will be performed for Shuttle experiment candidates such as the Acoustic Containerless Experiments System, the Combustion Science System, and the Containerless Measurement System.

Materials Experiment Operations is a consolidation of ongoing activities which provides a range of experimental capabilities for all scientific and commercial participants in the materials processing program. These include drop towers, aircraft and sounding rocket flights, Shuttle mid-deck experiments, and experiments for the Materials Experiment Assembly. These capabilities will enable users to develop different experiments in a cost-effective manner and allow a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, limited reflight of currently selected investigations on sounding rockets and on Shuttle/Spacelab missions is provided for in Materials Experiment Operations.

The Shuttle/Spacelab payload development activities have been transferred to the Physics and Astronomy Spacelab Payload Development and Mission Management area to be consistent with the reorganizational responsibilities with the Office of Space Science and Applications.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**RESEARCH AND ANALYSIS (MATERIALS PROCESSING)**

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Ground-based investigations, analysis and studies.....	12,000	13,100	13,100	14,000

OBJECTIVES AND STATUS:

The research and analysis activity provides the scientific foundation for all current and future projects in the materials processing in space program. Emphasis is being placed on ground-based research which is expected to be developed into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities leading toward privately funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1983 funding is being used to fund the continuation of three-year research projects proposed by leading members of the materials science community. Ongoing research is concentrated on scientific investigation and technology advancement in infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processing, combustion science, crystal growth, and containerless processing techniques. In addition, some cloud physics research will be initiated as low gravity research opportunities become available. Commercialization activities will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in materials processing in space projects, and negotiations with companies interested in undertaking joint space endeavors with NASA.

BASIS OF FY 1984 ESTIMATE:

Ground-based research and analysis will be continued in FY 1984 in the areas of containerless processing, crystal growth, solidification, fluid behavior, biological separation, combustion, and cloud physics. Prior materials processing in space research has brought three containerless processing techniques (acoustic,

electrostatic, and electromagnetic) to the design stage. **FY 1984** studies of crystal growth, solidification, and fluid behavior will continue in order to define the role of gravity-driven influences (convection, sedimentation, and buoyancy) in generic processing methods, and will concentrate on materials of technological significance (infrared and nuclear detectors, magnetic alloys and immiscible alloys). Major **FY 1984** efforts will also include studies of superconductors, metallic glasses, and other metastable phases where enhanced or new properties may be achieved. Arrangements with companies that may lead to joint ventures in space processing and manufacturing will continue to be reviewed in **FY 1984**. A small effort in space materials systems area will also be continued in **FY 1984** as part of an ongoing study effort to identify cost effective utilization of extraterrestrial materials.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

MATERIALS EXPERIMENT OPERATIONS

	<u>1982</u>	<u>1983</u>		<u>1984</u>
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Materials experiment operations.....	4,244	8,900	8,900	7,600

OBJECTIVES AND STATUS:

The Materials Experiment Operations program provides a wide range of opportunities for scientific (e.g., metastable superconducting state of Niobium-germanium compound) and commercial experiments (e.g., the INCO Technical Exchange Agreement on electroplating) in materials processing in space. Facilities generally used include drop towers, drop tubes, aircraft and sounding rocket flights. Development of Shuttle mid-deck experiments are also supported under this activity. The first materials experiment assembly hardware was completed in 1982 and is scheduled for launch in 1983.

BASIS OF FY 1984 ESTIMATE:

FY 1984 activities in materials experiment operations will continue basic research activities using mid-deck experiments, continue use of the materials experiment assembly (MEA-A), and ground-based, low gravity experimentation. The mid-deck experiments will include investigations which use the first version of acoustic containerless processing equipment and the first low gravity test of a method (isoelectric focused electrophoresis) for the separation of biological materials. Use of short-term, low gravity ground based facilities will be increased to take particular advantage of the new (91 meter) drop tube/tower which became available in 1982. This will be used to study the solidification of metastable and deeply undercooled alloys which may possess new and attractive physical properties.

COMMUNICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

COMMUNICATIONS PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Research and analysis.....	15,400	5,100	5,100	8,500	RD 9-4
search and rescue.....	2,300	3,700	3,700	3,800	RD 9-5
Technical consultation and support studies.....	2,600	2,600	2,600	2,700	RD 9-7
Experiment coordination and operations support.....	1,000	1,000	1,000	1,100	RD 9-9
Advanced communications technology satellite.....	---	---	20,000	5,000	RD 9-11
Total.....	<u>21,300</u>	<u>12,400</u>	<u>32,400</u>	<u>21,100</u>	

Distribution of Program Amount by Installation:

Goddard Space Flight Center.....	2,692	4,000	3,940	4,300
Jet Propulsion Laboratory.....	1,466	1,400	2,760	5,400
Ames Research Center.....	340	100	215	200
Lewis Research Center.....	16,100	5,300	24,205	10,200
Marshall Space Flight Center.....	---	---	100	100
Headquarters.. ..	702	1,600	1,180	900
Total.....	<u>21,300</u>	<u>12,400</u>	<u>32,400</u>	<u>21,100</u>

RESEARCH **AND** DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE **SCIENCE** AND APPLICATIONS

COMMUNICATIONS PROGRAM

OBJECTIVES **AND** STATUS:

The Communications program provides, among other objectives, the technology that allows the most effective use of the geosynchronous orbit and radio frequency spectrum. In prior years, a major portion of the program resources were concentrated in the research and analysis element of the program, which is focused on new communications subsystem technology.

In FY 1983, contracts are being continued with industry to develop a technology base in advanced communications for the 1990's. These efforts, which will be completed in FY 1984, will produce laboratory models of multibeam antennas and onboard switching, signal processing, and radio frequency components.

The Search and Rescue program uses satellites to aid in the detection and location of distress beacons carried by aircraft and ships. The demonstration and evaluation phase began in 1982 with the launch of the Soviet satellite, COSPAS 1. The search and rescue antennas, receivers, signal processor and transmitter for the NOAA-E spacecraft have been integrated and tested, completing all necessary preparations for launch of NOAA-E in 1983. In FY 1982, the ground station development was also completed. Three ground stations were installed at search and rescue facilities operated by the U.S. Coast Guard and the U.S. Air Force. Experimental distress transmitters operating at 406 MHz have been completed and deployed in accordance with the demonstration and evaluation plan. This work has been done in cooperation with Canada, France, and the Soviet Union. Payloads will be flown on six meteorological spacecraft operated by the National Oceanic and Atmospheric Administration, and at least two Soviet COSPAS spacecraft.

Technical consultation and support will continue to provide for studies of radio interference, propagation, and special system studies required for the growth of existing satellite services and the inclusion of new satellite applications. Support to the Department of State, the Federal Communications Commission, and the National Telecommunications and Information Administration, in preparing for a series of World Administrative Radio Conferences on geostationary orbit planning for all space services is continuing, as are direct broadcast satellite mobile communications planning activities.

Experiment coordination and operations support was continued for ATS-1, 3, and 5 satellites in FY 1982. The relocation of ATS-1 to enable continued operations in the Western Pacific has been completed. Current efforts are directed at developing user protocol documents to assist other agencies in the use of these satellites for public service. The Advanced Communications Technology Satellite (ACTS) technology development process is being continued in FY 1983.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>RCH AND</u>	<u>YSIS (COMMUNICATIONS)</u>		
	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Research and analysis.....	15,400	5,100	5,100	8,500

OBJECTIVES AND STATUS:

The Communications Research and Analysis program provides the advanced technology base in the field of satellite communications. Currently, there are seventeen U.S. commercial communications satellites located above the Equator in view of the United States. Applications are on file for 24 more to be launched by the mid-1980's. These satellites will exhaust the capacity of the geostationary arc at the lower frequency bands currently in use. Capacity increases beyond the mid-1980's will require systems using new technology advances that function most efficiently in higher frequency bands.

In FY 1980 and 1981, a series of technology development contracts was awarded to U.S. industry to produce proof-of-concept models of components and subsystems that will permit satellite communications operations in the 30/20 GHz frequency band. Contracts were awarded in the following technology areas: multiple spot-beam spacecraft antennas, spacecraft matrix switches, a spacecraft baseband processor, a 30 GHz spacecraft receiver, a 20 GHz solid state spacecraft transmitter, a 20 GHz spacecraft traveling-wave tube amplifier, a traveling-wave tube power supply, and components for low cost ground terminals. Several of these contracts have been jointly funded by NASA and the Department of Defense because of their potential applicability to future military systems. The proof-of-concept models produced by these contractors will be delivered in 1983 and 1984, and will undergo limited end-to-end testing to evaluate their system level performance.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the research and analysis funding will allow for the completion of the development of the Advanced Communications Technology Satellite (ACTS) proof-of-concept models, allow intensive in-house system testing to be conducted, and allow additional definition of ACTS space and ground technology requirements. In addition, effort will be initiated to define new technology for intersatellite links.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

SEARCH AND RESCUE

	<u>1982 Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget Estimate</u> (Thousands of	<u>Current Estimate</u> Dollars)	<u>Budget Estimate</u>
Search and rescue.....	2,300	3,700	3,700	3,800

OBJECTIVES AND STATUS:

The Search and Rescue program is demonstrating the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate distress signals from general aviation aircraft and marine vessels during an emergency. A satellite system can provide more comprehensive coverage than the irregular coverage provided by overflying aircraft now relied upon by permitting rescue forces to arrive at the accident scene more quickly than is presently possible. Recent experience with the COSPAS-1 spacecraft, launched by the Soviet Union in June 1982, has shown that a satellite orbiting in low Earth orbit can detect the emergency beacons operating at 121.5 MHz presently carried by aircraft and ships much more quickly and precisely than can random aircraft overflights. Actual test results indicate that a satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers. The results also show that this same system can locate a proposed new beacon (using the recently allocated 406 MHz frequency), with its stronger and more stable signal, to better than 5 kilometers accuracy.

This multiagency program is being conducted jointly with Canada, France, Norway, the United Kingdom and the Soviet Union. The United States will provide a spacecraft, antennas, launch vehicle, and U.S. ground stations. The Canadians will provide the space telecommunications equipment and a ground station. France will provide an onboard processor and receiver and a ground station. The Soviet Union will launch and maintain two spacecraft operationally compatible with the United States, French and Canadian systems, and will operate their own ground stations. Norway will participate in the joint project as an investigator by providing additional experimental test beacons and an interoperable ground station in Norway. The United Kingdom will provide additional test beacons in the U.K. search and rescue areas. In addition to NASA, United States participants include the Department of Defense and Department of Transportation, which have purchased ground stations and will participate in the program demonstration and evaluation phase. NOAA is providing the spacecraft.

All activities required to support the demonstration and evaluation phase of the multiagency program are completed. The NOAA-E spacecraft is complete; the French and Canadian search and rescue instruments have been delivered and integrated; and the spacecraft has completed thermal/vacuum testing, and is scheduled for launch in early 1983. The three search and rescue ground stations have been completed and are in use with COSPAS-1. New experimental distress transmitters operating at 406 MHz have been developed. Excellent progress has been made in evaluating the effectiveness of the system by using COSPAS-1.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding is required to evaluate the performance of the on-orbit search and rescue system to determine overall system effectiveness, location accuracy, and impact on search and rescue operations. FY 1984 funds will also be used to complete the integration and test of the search and rescue instruments on the NOAA-F and G spacecraft. In addition, work will continue in FY 1984 on the NOAA-H, I and J spacecraft to permit an extension of the search and rescue spacecraft coverage on an interim basis until an operational system can be deployed.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

TECHNICAL CONSULTATION AND SUPPORT STUDIES

	1982	1983		1984
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of	Dollars)	
Technical consultation and support studies.....	2,600	2,600	2,600	2,700

TI AND STATUS:

Radio interference, propagation, and system studies being conducted under this program are required to enable the growth of existing satellite services and the extension of new satellite applications. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. These efforts provide a technical basis for regulatory and policy studies and are needed to continue orderly satellite services. Emphasis is being placed on on-orbit and spectrum utilization studies which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary orbit and radio spectrum. NASA's unique resources and expertise, developed over more than 15 years, are also used, upon request, to support the Federal Communications Commission, National Telecommunications Information Administration, Department of State, Federal Emergency Management Agency, and other organizations. NASA will assist in the preparation for the 1983 Regional Administrative Radio Conference to be held in Geneva in June and July of 1983.

The technical consultation and support program has made it possible to implement, on a commercial and nonexperimental basis, remote sensing, mobile communications, and broadcasting by satellite. These capabilities are essential to a broad range of public and private sector applications such as commercial mobile telephone, direct television and audio broadcast, paging, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. These capabilities will provide valuable contributions to domestic and international economic and social development.

BASIS OF FY 1984 ESTIMATE:

Major emphasis during FY 1984 will include continued activities to assure space communications development through adequate U.S. strategies, positions, technologies, and propagation experiments needed to support U.S. positions at International Telecommunications Union World Administrative Radio Conferences scheduled for the 1984-1988 time frame.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

EXPERIMENT COORDINATION AND OPERATIONS SUPPORT

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1983 <u>Current</u> <u>Estimate</u>	1984 <u>Budget</u> <u>Estimate</u>
Experiment coordination and operations support....	1,000	1,000	1,000	1,100

OBJECTIVES AND STATUS:

The objective of this program is to continue experiment support for ATS-1, -3, and -5 spacecraft and to appropriately document and archive a wide range of user experiments and demonstrations in the application of satellite communications. Past experiments on experimental satellites (Application Technology Satellite (ATS) series and Communications Technology Satellite (CTS)) have generated great interest nationally and internationally in satellite telecommunications. Nearly 400 communication experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites; thus providing users with the experience necessary for making informed decisions regarding their communication functions. NASA's stimulus in encouraging use of these unique facilities has led to wider application of commercial satellites, which can now better meet the need for flexibility and continuity of services. ATS-1 and ATS-3 are currently used for VHF voice communication experiments in health care delivery, education, public safety, emergency communications, mobile land and maritime communications, research support and data communication. The major experiments on ATS-1 involve communications in the islands of the Pacific Basin where, for much of that region, the ATS-1 is the only source of inter-island communications.

A major accomplishment of this program was the completion in FY 1983 of the first phase of the Pacific Basin Communications Study, funded by the National Telecommunications Information Administration and NASA, which assessed present telecommunication systems in the Pacific island regions, examined user needs and services, and proposed alternative technological solutions for a regional satellite-based communications system.

Other activities in this program include planning for educational and public service communication, continuing support for the management and operation of the Denver Satellite Access Facility, and the coordination of ATS user experiments with other Federal agencies.

BASIS OF FY 1984 ESTIMATE:

ATS-1, 3 and 5 operations will be continued during FY 1984 as will support for the Denver Satellite Access Facility. The Pacific Basin Study will conclude with an evaluation of the technical characteristics of a Pacific island satellite-based telecommunications network. A study of ATS-1 follow-on options and alternative low density system concepts will also be conducted in FY 1984.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

		<u>COMMUNICATIONS TECHNOLOGY SATELLITE (ACTS)</u>		
	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Advanced communications technology				
satellite.....	-----	---	20,000	5,000

OBJECTIVES AND STATUS:

The objective of the Advanced Communications Technology Satellite (ACTS) project is to prove the feasibility of advanced communications satellite technologies in the environment of space and representative Earth atmospheric conditions. The specific technologies which will be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequencies and at baseband; (d) advanced system network concepts, and (e) dynamic rain compensation techniques. The ACTS project will greatly enhance **U.S.** space communication technology in the 1990's, preserving this important industry from dominance by emerging competitors.

The request for proposals will be released to industry in early 1983 based on the assumption of significant cost contribution by industry. The launch date is projected for mid-1988.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$20 million in FY 1983 is the result of a Congressional addition over the FY 1983 budget request. These funds will be used to initiate the ACTS project.

BASIS FOR FY 1984 ESTIMATE:

The FY 1984 funding is required for initiation of design and development activities on the Advanced Communications Technology (ACTS) Satellite project. The current planning estimate for the government cost on the ACTS project is approximately \$350 million. This estimate assumes that industry will make a significant cost contribution toward the development of the Advanced Communications Technology Satellite with a resultant sharing of the total program cost. However, the exact nature and amount of possible industry contribution will not be known until proposals have been received from industry.

INFORMATION
SYSTEMS



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

INFORMATION SYSTEMS PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of	1983 <u>Current Estimate</u> Dollars)	1984 <u>Budget Estimate</u>
Data systems.	4,300	7,500	7,500	8,900
<u>Distribution of Program Amount by Installation:</u>				
Marshall Space Flight Center.....	25	---	75	100
Goddard Space Flight Center.....	1,945	4,400	3,525	4,525
Jet Propulsion Laboratory	2,100	2,600	3,800	4,100
National Space Technology Laboratories	100	200	---	---
Headquarters.... ..	<u>130</u>	<u>300</u>	<u>100</u>	<u>175</u>
Total.....	<u>4,300</u>	<u>7,500</u>	<u>7,500</u>	<u>8,900</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS

INFORMATION S I

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Information Systems programs are to: develop and demonstrate advanced capabilities for managing, distributing, and processing data and information; implement information systems standards and provide transportable common software in order to lower data systems costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and the space science and applications projects.

This program provides for timely development of data systems capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data systems development risks and the chance of late data delivery.

BASIS FOR FY 1984 ESTIMATES:

The FY 1984 information systems funding is required to provide support for space science and applications programs. Specifically, funds are required: to continue development of the oceans and atmosphere pilot projects, which are prototypes of possible future data systems, at the Jet Propulsion Laboratory and Goddard Space Flight Center; to complete implementation of online catalogs and common software for climate and Oceans data that support ongoing discipline research; and to continue development of data management standards with flight projects, discipline program offices, and other NASA program offices.

The FY 1984 funding will also provide for: the completion of transportable applications software systems; upgrading of the National Space Science Data Center and the Science and Applications Computing Center; technical data system support for flight projects and Spacelab missions; the continuation of high priority data systems standards research and development activities; and definition of joint pilot activities with the National Oceanic and Atmospheric Administration, the Department of the Interior, and the National Bureau of Standards.

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1984 BUDGET ESTIMATES
BUDGET SUMMARY

OFFICE OF EXTERNAL RELATIONS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u> <u>Budget</u> <u>Estimate</u>	<u>Page</u> <u>Number</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)		
Technology dissemination.....	5,700	3,200	5,700	2,200	RD 11-4
Technology applications.	<u>2,300</u>	<u>800</u>	<u>3,300</u>	<u>1,800</u>	RD 11-4
Total.....	<u><u>8,000</u></u>	<u><u>4,000</u></u>	<u><u>9,000</u></u>	<u><u>4,000</u></u>	

Distribution of Program Amount by Installation:

Johnson Space Center.....	25	---	---	---
Kennedy Space Center.....	25	---	250	55
Marshall Space Flight Center.....	235	195	265	195
National Space Technology Laboratories	20	---	20	---
Goddard Space Flight Center.....	630	390	999	380
Jet Propulsion Laboratory	471	50	743	265
Ames Research Center.....	75	50	138	105
Langley Research Center.....	597	235	771	435
Lewis Research Center.....	40	---	312	240
Headquarters	<u>5,882</u>	<u>3,080</u>	<u>5,502</u>	<u>2,325</u>
Total.....	<u><u>8,000</u></u>	<u><u>4,000</u></u>	<u><u>9,000</u></u>	<u><u>4,000</u></u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 BUDGET ESTIMATES

OFFICE OF EXTERNAL RELATIONS

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVE AND JUSTIFICATION:

The Technology Utilization Program is designed to enhance national economic growth and vitality through the transfer of new technology from NASA research and development programs to the nonaerospace sectors of the economy. In addition to increasing use of aerospace technology in the United States and abroad, such technological advances have found use in important sectors such as medicine, agriculture, and industry. Specific objectives of the program are:

- o To accelerate and facilitate the application and use of new technology thus shortening the time between development of advanced technology and space technologies and their utilization in the economy;
- o To encourage multiple secondary uses of NASA technology in industry, education, and Government where a wide spectrum of technological problems and needs exist;
- o To understand more fully the technology transfer process and its impact on the economy; and
- o To develop applications of NASA's aerospace expertise--its technology, technologists, and unique facilities--to the nonaerospace needs of the Nation.

Since the program's inception in FY 1962, many transfer mechanisms have been developed to facilitate the use of aerospace technology in the public and private sectors of the economy. These mechanisms include publications and announcements, industrial conferences, and seminars. Through such efforts, NASA has developed a viable working relationship with U.S. industry across a broad front of commercial enterprises. In FY 1984, NASA proposes to build on its technology transfer activities to strengthen expanded Government-industry cooperation.

OBJECTIVES AND STATUS:

Conversion of NASA Tech Briefs, one of NASA's primary new technology transfer and announcement mechanisms, to paid subscription, is being examined. In 1982, 75,000 free distribution copies were made available

routinely to industrial scientists, engineers, and businessmen each quarter to stimulate and promote the application and use of NASA-developed technologies for commercial purposes.

During **1982**, the NASA dissemination center network provided nearly 15,000 U.S. industrial client firms with technical information and technology transfer services based on problem-related inquiries. Client firms, especially in the industrial manufacturing sector, have found information and technology transfer services to be beneficial in the development of new or improved products or processes. The NASA-sponsored Computer Software and Management Information Center also had an outstanding year in the sale/lease of NASA-developed computer programs to industry. The entire university-based dissemination network received over **\$4,000,000** from industry last year for information dissemination and technology transfer services, reflecting substantial continued interest and utility of these NASA-supported programs.

NASA continued its series of industrial conferences and seminars at selected NASA field centers under co-sponsorship with the American Institute of Aeronautics and Astronautics (AIAA). A fall conference on materials technology at Langley Research Center marked a change in the conference/seminar formats. Prior events covered a broad range of scientific and engineering advances resulting from projects conducted at the host Center. The new format focuses on selected technological disciplines or fields of interest so that more in-depth treatment of subject matter is made possible. In addition, a special conference was held at the Johnson Space Center recently to relate specific technological advancements in Shuttle tile development for possible applications in industry.

Emphasis during FY **1982** was placed on bioengineering, rehabilitation, manufacturing and productivity applications. Each of the projects funded during **1982** had joint participation from user agencies or industry. A major milestone was reached in bioengineering, when the Programmable Implantable Medication System was successfully implanted and tested in several diabetic animals. An ultrasonic bolt monitor, which can be used to determine if a bolt has a hairline crack through the use of ultrasonic sound, was successfully demonstrated on mine roof bolts (bolts used to hold the ceiling or roof of a coal mine in place). The Bureau of Mines is presently field testing this instrument. NASA and the National Institute of Handicapped Research successfully commercialized a new wheelchair concept for use in commercial air travel, and a major commercial airline has ordered **22** chairs for use in its new Boeing **767**.

CHANGES FROM FY 1983 ESTIMATE:

The increase of \$5.0 million in FY 1983 which is the result of Congressional action on in the FY 1983 appropriation request, will provide for dissemination activities at approximately the FY 1982 level, and will allow continuation of ongoing as well as several new efforts in technology applications.

BASIS OF FY 1984 ESTIMATE:

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1984</u> Budget <u>Estimate</u>
Technology dissemination.....	5,700	3,200	5,700	2,200

In FY 1984, NASA will continue to provide for the widest practicable dissemination of technical information resulting from NASA research and development programs. Funding in FY 1984 will allow for continuation of the dissemination of information concerning NASA technology, but at a somewhat lower level than FY 1983. NASA will attempt to maintain price levels for technical information for United States industry so that access by small business users will not be seriously impaired.

NASA is currently conducting its evaluation and benefit analysis activities to determine areas of United States industrial need where aerospace technology may have particular applicability. In addition, program elements are being reviewed in detail to determine the practicality of greater private sector involvement in the technology transfer process. In FY 1984, program evaluation and benefit analysis activities will be phased out: however, publication inquiry support and scientific and technical information data base support for the NASA dissemination center network will be maintained at the NASA Scientific and Technical Information Facility.

Technology applications.....	2,300	800	3,300	1,800
------------------------------	-------	-----	-------	-------

In FY 1984, the applications engineering program efforts will be focused on targeted opportunities in the biomedical field; however, a portion of the program will sustain a **small** effort in industrial automation (robotics). NASA will continue to participate with industry, other federal agencies and universities to complete several high priority biomedical projects. Applications team activities will be maintained in support of selected feasibility studies designed to apply existing aerospace technology to biomedical and

rehabilitation problems identified in cooperation with the National Institutes of Health, other public sector medical organizations, and industry. To achieve this objective, NASA will reduce its level of support in the applications of aerospace technology in transportation, public safety, environment, and manufacturing.

AERONAUTICS AND
SPACE TECHNOLOGY

Aeronautical Research &
Technology

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES F

	1982 <u>Actual</u>	1983 <u>Budget</u> <u>Estimate</u> (Thousands of	1983 <u>Current</u> <u>Estimate</u> Dollars)	1984 <u>Budget</u> <u>Estimate</u>	Page <u>Number</u>
Research and technology base.....	172,758	196,600	197,700	227,800	RD 12-4
Systems technology programs.....	<u>92,042</u>	<u>35,400</u>	<u>82,300</u>	<u>72,500</u>	RD 12-27
Total.....	<u>264,800</u>	<u>232,000</u>	<u>280,000</u>	<u>300,300</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	150	150	200	200	
Marshall Space Flight Center.....	700	750	500	600	
Jet Propulsion Laboratory	500	500	500	500	
Goddard Space Flight Center	500	500	500	500	
Ames Research Center.....	86,000	95,000	96,000	122,200	
Langley Research Center.....	93,000	76,000	94,300	93,300	
Lewis Research Center.....	79,750	54,600	83,000	78,000	
Headquarters.	<u>4,200</u>	<u>4,500</u>	<u>5,000</u>	<u>5,000</u>	
Total.....	<u>264,800</u>	<u>232,000</u>	<u>280,000</u>	<u>300,300</u>	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

<u>Old Structure</u>	AERONAUTICS	R&T Base	Aerodynamics	Propulsion	Materials & Structures	A/C Controls & Guidance	Human Factors	Multi-disciplinary	Low-Speed	High-Speed	Systems Technology Programs	Low-Speed A/C Technology Prog.	Rotorcraft Operations Sys.	Advanced Rotorcraft Systems Technology	Advanced Rotorcraft Technology	Low-Speed Simul.	High-Speed A/C Systems Technology	High-Performance Flight Res.	HiMAT	HOST
	232.0	182.0	42.3	43.0	31.3	12.9	9.6	3.5	12.4	27.0	50.0	30.0	(1.5)	(5.6)	(13.5)	(9.4)	20.0	(13.3)	(1.1)	(5.6)
<u>New Structure</u>																				
<u>AERONAUTICS</u>	232.0																			
<u>R&T Base</u>	196.6	182.0									14.6									
Fluid & Thermal Physics	46.1		31.2	14.9																
Materials & Structures	25.5			1.4	24.1															
Controls & Guidance	11.3			0.7		10.6														
Human Factors	9.6						9.6													
Multidisciplinary	3.5							3.5												
Computer Science & Applic.	14.2		8.8	3.9	1.5															
Propulsion Systems	18.6			18.6																
Rotorcraft	21.8								12.4							9.4				
High-Performance Aircraft	35.7		0.3	2.9	0.3					27.0								5.2		
Subsonic Aircraft	10.3		2.0	0.6	5.4	2.3														
<u>Systems Technology Programs</u>	35.4										35.4									
<u>Rotorcraft Systems Tech.</u>	20.6												1.5							
<u>Guidance & Navigation</u>	1.5													5.6						
RSRA Flight Res./Rotors	5.6														13.5					
Advanced Rotorcraft Tech.	13.5																			
<u>High-Perf. A/C Sys. Tech.</u>	14.8																			
<u>High-Performance Flight Res.</u>	8.1																	2.1		
<u>Highly Maneuverable A/C Tech.</u>	1.1																		1.1	
<u>Turbine Eng. Hot Sect. Tech.</u>	5.6																			5.6

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the aeronautics program are to advance aeronautical technology to insure safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to support the Department of Defense in maintaining the superiority of the Nation's military aircraft; and to maintain the strong competitive position of the United States in the international aviation marketplace.

The FY 1984 program supports these objectives by providing for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical by in-house assessments, industry, military, and advisory groups, and other users of technology within and outside the Federal government. Emphasis will be placed on maintaining a strong discipline and vehicle oriented research and technology base, with focused systems technology programs in high-performance and subsonic aircraft and rotorcraft.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

Within the aeronautics research and technology base, an internal realignment of FY 1983 funding was implemented in order to place increased emphasis on high priority computer science and applications programs, and to provide additional support to Department of Defense activities within the high-performance aircraft discipline. Additional resources were provided to these discipline areas in FY 1983 by directing a modest decrease in activities across a broad spectrum of research and technology base disciplines and programs.

The increase of \$48 million in aeronautical research and technology activities is directly attributable to a Congressional increase that provides continuing support for selected ongoing programs in the advanced propulsion, subsonic aircraft and rotorcraft systems technology areas. In advanced propulsion, the Congressional restoration of funding allows work to continue in FY 1983 on advanced turboprop systems, general aviation/commuter engine technology, broad property fuels and the energy efficient engine. In subsonic aircraft, the Congressional action provided funds for continued effort on composite primary

aircraft structures, advanced transport operating systems, laminar flow control and energy efficient transport. In rotorcraft, the Congressional action provided additional funding for advanced rotorcraft technology.

BASIS OF FY 1984 BUDGET ESTIMATE:

The research and technology base program will build on the substantial results of the ongoing program, utilizing the unique **NASA** experimental facilities, research aircraft, computer capabilities, and expertise now in existence. Fundamental discipline efforts will continue to lead to significant advances in a number of areas: **nonintrusive** experimental test techniques and the development of computational methods to better understand and predict aerodynamic and thermodynamic characteristics associated with complex flows over aircraft and in propulsion systems to improve performance and reduce development costs; metallic, ceramic, polymer, and composite materials for high temperature engine applications and lightweight airframe structures; the development of analytical methods to improve life prediction and better understand and control the dynamic response of complex aircraft and engine structures; electronics and highly reliable, fault-tolerant aircraft control system software and architectural concepts; crew station technology and the capability of modeling pilot behavior in a multivariable environment; and a better fundamental understanding of alternative fuels and their potential impact on engine performance. The discipline and vehicle oriented research and technology base efforts in the various speed regimes will continue with wind-tunnel investigations on advanced aircraft and rotorcraft configurations, and examination of the effects of promising technology advances individually and in combination.

Systems technology activities will continue in the areas of rotorcraft, high-performance aircraft and subsonic aircraft. Rotorcraft systems technology will investigate guidance and control for all-weather operations, advanced rotor aerodynamics, composite **tilt** rotor blades and several other technologies aimed at improving performance and flying qualities of the **tilt** rotor vehicle class, and will make rotor systems research vehicle modifications leading to future X-Wing rotor system research. High-performance aircraft systems technology will include enhanced fighter performance involving flight evaluations of advanced concepts using special F-16 and F-111 aircraft. The proof-of-concept flight research phase of the **NASA/DARPA** X-29A forward swept wing vehicle will also begin. **Also** in FY 1984, increased effort will be provided in the turbine engine hot section technology (HOST) program in order to study a variety of means for increasing engine performance and durability. Subsonic aircraft systems technology will proceed in the field of composite structures suitable for safety-of-flight primary structure applications in large military and civil transport aircraft. Efforts will be initiated in both wing and fuselage structures and for advanced materials with increased resistance to damage and impact loads.

Numerical aerodynamic simulation is an important new initiative for FY 1984 in systems technology. This program leads toward major advances in the Nation's capabilities in computational fluid dynamics culminating in new powerful analytical techniques that will be invaluable in the design of future aerodynamic vehicles of all types.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	<u>1982 Actual</u>	<u>1983 Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>1984 Budget Estimate</u>	<u>Page Number</u>
Fluid & thermal physics research and technology	38,505	46,100	43,100	52,200	RD 12-5
Materials and structures research and technology	21,548	25,500	24,700	27,700	RD 12-7
Controls and guidance research and technology	7,119	11,300	11,900	12,800	RD 12-10
Human factors research and technology	8,218	9,600	10,200	11,200	RD 12-12
Multidisciplinary research.....	7,500	3,500	3,500	3,700	RD 12-14
Computer science and applications research and technology.	8,510	14,200	19,200	20,800	RD 12-15
Propulsion systems research and technology.....	18,616	18,600	16,600	28,500	RD 12-17
Rotorcraft research and technology. ...	20,175	21,800	23,000	23,300	RD 12-19
High-performance aircraft research and technology.....	29,029	35,700	38,000	38,600	RD 12-22
Subsonic aircraft research and technology.....	<u>13,538</u>	<u>10,300</u>	<u>7,500</u>	<u>9,000</u>	RD 12-24
Total.....	<u>172,758</u>	<u>196,600</u>	<u>197,700</u>	<u>227,800</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Fluid and thermal physics research and technology.....	38,505	46,100	43,100	52 ,200

OBJECTIVES AND STATUS:

The objectives of the fluid and thermal physics research and technology program are to: (1) advance the speed and scope of computations for the prediction of fluid dynamic flows over aircraft and in turbomachinery; (2) develop practical means to improve the aerodynamic efficiency and environmental acceptability of aircraft and propulsion systems; and (3) provide the experimental technology required for precise aerodynamic testing. The attainment of these goals will permit the confident design and development of new aircraft and engines with minimum time and cost while providing the widest range of design options.

Of the broad areas of application of fluid dynamics, the ~~most~~ advanced is that of external flows over wings, bodies, and simple combinations of the two. A new psuedo-spectral technique for solving Euler's equation of fluid motion has been applied to several difficult shock wave problems and has resulted in a three-fold increase in solution speed over standard techniques. Computation of internal and rotational flows in compressors and turbines is progressing at a rapid rate but is presently less accurate than that for external flows for design application because of the greater geometric complexity and impact of difficult viscous flow interactions. Nevertheless, during FY 1982, shock-free transonic flow codes were applied to the analysis of compressor blade flows, providing new understanding of the causes of flow separation. The research offers promise of design cost savings by reduction in the number of experimental blade sets normally required in compressor and turbine design.

Experimental studies to reduce fluid friction drag of airfoils, compressor and turbine blades, and complete aircraft have confirmed preliminary results showing 20 percent reductions in turbulent friction drag; and new wind-tunnel results have demonstrated that laminar boundary layers on transonic airfoils can be maintained over 90 percent of the airfoil's chord. Laminar flow research at supersonic speeds that was previously restricted to flight testing is now feasible in a new wind-tunnel design that quiets the flow to disturbance levels of free flight. Transition Reynolds numbers equal to those of free flight have been demonstrated in a pilot facility at a Mach number of 3.5.

Basic investigations of the combustion of liquid fuels have focused on the causes of soot formation and associated undesirable radiative heat transfer to combustor walls. These studies have defined the influence of fuel chemical properties as well as the mechanics of spray mixing and droplet evaporation on the combustion processes. Details of these studies are being integrated into analytical codes for ultimate application to the design of combustors with extended life.

The unique new cryogenic transonic wind tunnel, the National Transonic Facility, was completed in FY 1982 and is undergoing final checkout before beginning a test program to explore the effects of Reynolds number on aircraft performance, maximum lift capability, and stability and control. New models of a typical fighter and a transport aircraft were completed, using recently developed fabrication techniques, and have been validated for the extreme cryogenic test conditions.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$3.0 million reduction in fluid and thermal physics research and technology base funding in FY 1983 is primarily attributable to the redirection of resources in order to support high priority program requirements in the computer science and applications and high-performance aircraft program areas. To achieve this objective, funding will be reduced for fluid and thermal physics research tasks relating to aircraft wake vortex flows and minimizing noise generation in advanced turbomachinery.

BASIS OF FY 1984 ESTIMATES:

Research in computational fluid mechanics during 1984 will be maintained at the current funding levels; however, the natural development of the science will bring greater emphasis on more exact fluid equations and more complex geometries such as complete aircraft, including the empennage, and the rotating flow passages in turbomachinery. Continued effort will be made to increase computational speed and accuracy through algorithm developments which will produce a more rapid convergence of numerical iterative procedures. Computational advances in flow prediction in turbomachinery will be supplemented by experimental measurements utilizing specialized test rigs designed for validation of computer codes and simplified to allow isolation of the effects of individual physical phenomena.

Turbulence research will be directed in greater part toward flow visualization for characterizing the typical flow structures convected downstream in turbulent boundary layers. Increased attention will be given to the effects of noise and surface irregularities on the transition from laminar to turbulent flows. This research will lead to improved methods to predict and reduce aircraft drag.

Combustion research will focus ~~more~~ sharply on fundamentals influencing the chemical and related physical progress of the heat release process. Experiments will be designed to identify purely chemical effects as compared with physical-chemical influences known to exist during combustion of sprayed droplets in typical engine combustors.

Experimental aerodynamics will place emphasis on the achievement of higher levels of maximum useful **lift** from wings and other airfoils. This research will be designed to meet the needs for increased maneuverability for fighter aircraft at both transonic and supersonic speeds, as well as for transport configurations where increased high lift permits design trade-offs leading to increased performance. During FY 1984, the capabilities of the National Transonic Facility will be utilized to provide for real-time assessment of the aeroelastic deformations of the models and studies will be conducted to determine the optimum means for simulation of propulsion effects. Important decision milestones on the use of magnetic balance systems and adaptive walls should be reached during FY 1984. The wall and balance support systems in wind tunnels constitute the largest remaining sources of error in wind-tunnel data.

	1982 <u>Actual</u>	1983		1984
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Materials and structures research and technology.. .. .	21,548	25,500	24,700	27,700

OBJECTIVES AND STATUS:

The objectives of the materials and structures research and technology program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) further analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and (4) generate research data to promote improvements in performance, safety, durability, and economy in civil and military aircraft. Areas of emphasis include high temperature engine and airframe materials and structural concepts; composite materials application, life prediction, thermal and dynamic response, and **aeroelasticity**; and ~~more~~ accurate and efficient integrated design methods for airframes and engines.

During the past year, a number of significant accomplishments were realized. The cure temperature of PMR-15 composites was reduced by 100°F through modifications of the matrix-resin chemistry. As a result, these

high temperature polyimide composites for engines and airframes can be produced more readily with lower expenditures for energy and capital equipment. Grain boundary oxidation was determined to be the major factor affecting the fatigue life of powder-metallurgy superalloys and the chemical mechanisms controlling hot corrosion of superalloys were identified; these research results provide the basis for subsequent work to increase the useful service life of turbine hot section components. A formal procedure was developed which automatically optimizes turbine fan blades for steady state, vibratory, impact, fatigue and flutter considerations. In aeroelasticity research, adaptive digital active flutter suppression was demonstrated for the first time. The effect of angle-of-attack on flutter was also demonstrated. An F-16E model with a cranked arrow wing underwent wind-tunnel testing and was shown not to have flutter problems. In composites research, by using anisotropic elasticity principles, a method was developed to determine the strength of angle plied laminates considering stress singularities at cracks, corners and free edges. In studies on thick composites for use in heavily loaded airframe applications, both strain-to-failure and fracture toughness were found to decrease as thickness increased. Intensive studies of impact response characteristics and delamination behavior have led to the identification and initial assessment of several promising resin compositions. A wide collection of improved optimization codes and design-oriented analysis methods have been developed and assembled. These are being integrated into a computer application system for the evaluation and design of a wide range of aerospace vehicles.

FY 1 BUDGET ESTIMATES:

The \$0.8 million decrease in materials and structures research and technology base funding was implemented in order to direct additional resources toward new high priority requirements in the computer science and the high-performance aircraft disciplines. The reduction in the materials and structures area was accomplished by decreasing the scope of the effort in lubrication, life prediction, and unsteady aerodynamics in FY 1983.

BASIS OF FY 1984 ESTIMATE:

Research on high temperature engine materials will emphasize new materials, in particular carbon-carbon, intermetallics, ceramics and tougher, high temperature polymers. Research on improved processing of superalloys and process modeling-of material response under thermal loading will be increased, as will the effort to obtain a fundamental understanding of the roles of cobalt, columbium and tantalum in superalloys. Life prediction of materials using viscoplastic modeling techniques will be stressed. The powder aluminum program for high speed airframe structural applications, now in its second year, will continue its planned growth.

In the engine structures and structural dynamics programs, research will be focused on the development of fundamental understanding of the behavior of engine seals and rotor dynamics as well as development of accurate and affordable nonlinear analysis methods and optimization methods for rotating systems. Tribological research will increase understanding of adhesion, friction, wear and lubrication of metallic and ceramic materials.

The principal thrusts in composite materials will continue to be durability, damage tolerance and the development of tougher composites. Intensive studies will be conducted in **FY 1984** in the following areas: impact response; delamination; damage tolerant concepts such as buffer strips, bonded stringers, and translaminar stitching; and polymer synthesis, characterization and processing. Special attention will be directed at developing an understanding of the relationship between resin properties and composite properties as resin improvements often do not result in corresponding improvements in the properties of composites. The composite structures effort will be directed to exploration of buckling behavior and post-buckling response.

In loads, dynamics, and aeroelastic research, the **FY 1984** program will emphasize improved unsteady aerodynamics prediction methods, particularly in the transonic speed range. Aeroelastic analysis tools will be developed and experimentally validated for application to aircraft and to turbine engine rotating components. Active and passive control of aeroelastic behavior will be a major focus. The Drones for Aeroelastic and Structural Testing (DAST) program will provide a flight validation for a flutter suppression system installed on a Firebee drone that has a transport aircraft type supercritical wing. A series of DAST flights are planned in **FY 1984** to investigate the flutter suppression system design, compare predicted versus measured flutter boundaries, and determine performance of a gust/maneuver load alleviation system.

The joint NASA/FAA program in transport crash dynamics has resulted in a crash scenario being developed for a full scale crash test of a Boeing 720 transport aircraft. Work related to the development of required instrumentation to support a **FY 1984** crash test will be conducted. Fuselage component drop tests will be conducted to obtain necessary structural performance data to support the analytical modeling required for the 720 crash test.

In the area of aircraft integrated analysis and design methods, efforts will focus on the optimization of the structural and aerodynamic configuration using performance and operating costs as design constraints. A large-scale optimization of a transport aircraft wing for fuel efficiency has been defined as a long-term task on which to focus the new methodology.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Controls and guidance research and technology	7,119	11,300	11,900	12,800

OBJECTIVES AND STATE

The objectives of the aircraft controls and guidance research and technology program are to: (1) develop architectures for flight crucial systems for future aircraft and to devise analytical methods and techniques for assessing the reliability and performance of complex integrated fault-tolerant flight control systems; (2) develop mathematical control laws and design methods for extending the performance envelope and reliability of future civil and military aircraft; and (3) investigate emerging technologies which offer future alternative approaches for continued aviation safety and efficiency. Major program elements are: applied control theory, flight path guidance, architectural concepts, system assessment methods, and environmental effects research.

Flight crucial systems research is a major element in the controls and guidance program, and excellent progress has been made in developing this technology. Engineering models of two pioneering fault-tolerant computers, fault-tolerant multiprocessor (FTMP) and software implemented fault tolerance (SIFT), were completed and evaluation initiated at the Langley Research Center. CARE III, the computer aided reliability estimation program, an important analytical tool for assessing the reliability of fault-tolerant systems, has been developed and is undergoing final evaluation. In early 1983, the Avionics Integration Research Laboratory (AIRLAB) at the Langley Research Center commences important research in highly integrated, fault-tolerant electronic systems for aircraft and spacecraft. Concern with the effects of lightning on digital electronics has led to increased research activity both in understanding lightning phenomena and in developing protective techniques. The effectiveness of newly developed protective schemes is being evaluated using induced voltage levels determined from analysis of flight data. Other activities in this area have resulted in a system for random injection of lightning-induced upset transients into microprocessors to characterize the effects.

Significant advances have been made in the determination of a design data base for vehicles with highly-augmented controls. Shuttle data have been analyzed to assess the flying qualities and improve the generic design process and modeling techniques for future aircraft. Improvements in analytical techniques provide

the capability to determine the influence of different active control concepts on aircraft stability, performance and configuration. Aircraft flight experiments have been conducted to validate advanced control laws which improve aircraft performance in the presence of gusts, clear air turbulence and other disturbances without limiting the control system effectiveness in other flight regimes.

CHANGES FROM FY 1983 BUDGET ES 1

The \$0.6 million increase in the controls and guidance research and technology area reflects an internal realignment of the research and technology base to provide additional resources for fault-tolerant avionics research activity in FY 1983.

BASIS OF FY 1984 ESTIMATE:

In the area of flight crucial controls, advanced fault-tolerant architectural concepts will be evaluated in the AIRLAB. These concepts will be derived from earlier evaluation of the engineering models of fault-tolerant computers, SIFT and FTMP and from specific system studies. One architectural concept to be evaluated is from a study for an integrated flight and propulsion control system for a high-performance aircraft. Another concept will be for a generic fault-tolerant avionics system for both aircraft and spacecraft applications. To demonstrate the reliability of these systems, research will continue on validation methodology through a series of grants at several key universities with the principal investigators doing research in the AIRLAB. Increased emphasis will be placed on fault-tolerant software with two significant approaches, N-version programming and recovery blocks, evaluated to determine the best approach. The environmental effects area will emphasize the design of concepts and circuits to protect electronics in the presence of lightning strikes. In the propulsion controls area, the principles of fault-tolerant design will be applied to improve system reliability. These concepts will be evaluated in a full scale engine test facility. In an important new area, restructurable controls, the fault tolerance or reconfiguration in the presence of failures will be applied to the entire flight control system and airframe. Research on advanced redundant sensors and actuator concepts will continue.

In the control theory area, the research effort will increase in highly or super augmented aircraft controls. In the design of these aircraft, weight and natural stability are traded for performance, and the aircraft becomes totally dependent on the flight control system. Examples of such aircraft are the F-16 and the Shuttle. Research will provide a data base which includes flying qualities, control power requirements, and design considerations. The concept of non-linear controls will be evaluated for application to high-performance aircraft operating at high angles-of-attack.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of	Dollars)	
Human factors research and technology	8,218	9,600	10,200	11,200

OBJECTIVES AND STATUS:

The objective of the human factors research and technology program is to provide a technology base for solving human problems impeding the growth and safety of aviation. This is accomplished by developing a fundamental understanding of the capabilities, limitations and tendencies of aircrew members in interacting with each other, with cockpit systems and with the air traffic control system. There are four areas of emphasis in the human factors program: flight management, simulation technology, aviation safety, and research methods.

The flight management research program has continued to develop a basic understanding of information transfer, decision making and resource management in the cockpit in order to provide a data base for improved cockpit systems and operational procedures. In this area, research on Cockpit Display of Traffic Information (CDTI) is continuing in cooperation with the Federal Aviation Administration (FAA). A number of studies have been accomplished on display format, content, symbology and size. In FY 1982, simulation studies demonstrated an increase in runway throughput (landings and takeoffs) of up to 20 percent through the use of CDTI. The display used in these studies employed a horizontal plan view format which allowed greater visual perception of the distribution and flow of aircraft in terminal area operations. More recently, a three-dimensional perspective display has been developed which provides pilots with a better understanding of the vertical situation. Evaluation of this new display format is continuing. Other flight management research is focused on developing strategies for allocating functions to crew members and to automation of advanced cockpits. This research was initiated in FY 1982 with a field study of the effect on aircrews of increases in automation in modern aircraft such as the DC-9-80 and the 767. The overall goal of this program is to develop function allocation guidelines which make maximal use of advanced automation technology in view of human capabilities and limitations.

Simulation technology research is aimed at increasing the degree to which man-in-the-loop simulation can replace actual aircraft flight time in research, development and training. Work is continuing on improved simulation of weather hazards, methods for determining required levels of simulation fidelity, and

techniques for assessing simulation system performance. Recent accomplishments include definition of required simulation fidelity for the flare maneuver and for wake vortex encounters.

The goal of the aviation safety research program is to identify the physical, psychological and procedural aspects of the aviation environment which tend to induce human error. The two major projects in this area are the Aviation Safety Reporting System (ASRS) which NASA is continuing to manage ~~for~~ the FAA, and a joint NASA/Army/Air Force program to assess the effects of fatigue and circadian desynchronosis on aircrew performance. A review of existing knowledge in this area is being completed, and a field study using short-haul crews has been undertaken.

The goal of the research methods area is to develop crew workload and performance methods which can aid in assessing the relative merits of alternative man/machine interface designs. An empirical evaluation of commonly used workload measures has been completed, and a workload assessment has been completed.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$0.6 million increase in the funding for human factors research and technology activities in FY 1983 supports increased visual scene research associated with the Man-Vehicle Systems Research Facility at the Ames Research Center.

BASIS OF FY 1984 ESTIMATE:

Flight management research will continue to encompass CDTI and the human implications of increased cockpit automation. The CDTI program will change focus from part task simulation studies to full mission scenarios as two major simulators (DC-9 and 727) become available in FY 1984. Application areas will turn toward the implications of CDTI for collision avoidance systems, and toward the study ~~of~~ interactions of multiple aircraft equipped with CDTI. The cockpit automation research will increase and encompass basic research on the interaction between crews and advanced cockpit information input/output systems such as multi-function programmable keyboards and touch-sensitive flat panel displays.

In simulation technology, a model for predicting needed simulation fidelity levels will be evaluated using F-14 flight information, and a major effort will be undertaken to develop the methodology for using full mission simulation to evaluate the effects of malfunctions and other systems problems on crew decision making. Research will continue on improving the capability to simulate weather hazards, and to assess simulation system performance. A physiological measure of brain activity, called evoked potential, will be investigated as a method of evaluating the psychological fidelity of a simulation to the human subject.

Fundamental research on how the human visual system perceives computer generated imagery will focus on developing methods for minimizing graphic distortion and misperception of information.

In the area of aviation safety, both the fatigue study and the ASRS will continue. Attempts will be made to increase the use of the ASRS by general aviation pilots. The fatigue and circadian desynchronosis study will expand to include crews on long-haul flights. Differences between commercial air carrier crews and Air Force crews, who differ in age by an average of 20 years, will be investigated.

The research methods area will continue to emphasize workload measurement research. The focus will evolve from the investigation of the components of the subjective workload phenomena, and from an evaluation of available measures, to the development of guidelines for the use of workload metrics for various applications.

	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Multidisciplinary research.....	7,500	3,500	3,500	3,700

OBJECTIVES AND STATUS:

The objective of the multidisciplinary research program is to conduct novel, long-range, multidisciplinary research related to aeronautics. This research is conducted principally at universities through: (1) the Graduate Program in Aeronautics which supports graduate training and research relevant to both NASA and the universities and conducted, at least in part, at a NASA research center using NASA facilities; and (2) the Computational Fluid Dynamics (CFD) Training program initiated to support graduate CFD training programs in selected universities. The Graduate Program in Aeronautics was started at the behest of Congress and assures the availability of skilled researchers in the field of aeronautics and provides for excellent interaction among students, faculty and NASA center personnel in the conduct of research. The CFD training program is providing for the development of interdepartmental university curricula and sponsoring graduate CFD training in response to the rapidly escalating need for specialists by NASA, DOD and the national aerospace industry.

BASIS OF FY 1984 ESTIMATE:

The research and graduate student support sponsored under this activity will continue to address a broad range of innovative topics to insure an adequate source of well-trained researchers necessary to contribute

to the long-term growth in aeronautics technology. The university research formerly conducted under the Fund for Independent Research (FIR) and the Joint Institute of Advancement of Flight Sciences will be supported through the disciplinary research and technology base programs.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Computer science and applications research and technology.	8,510	14,200	19,200	20,800

OBJECTIVES AND STATUS:

The objective of the computer science and applications program is to develop an understanding of the fundamental principles underlying aerospace computing and the relationship and trade-offs between algorithms and computing architectures: and to apply this fundamental insight in order to advance computational concepts and improve system architectures. The program being initiated in FY 1983 is guided by a program plan which was completed in 1982. This program has four major areas: concurrent processing, highly reliable cost-effective computing, information management, and computational facilities.

Concurrent processing addresses system architectures and algorithms for computationally-intensive problems in aerospace research, such as computational fluid dynamics and image processing. A new Research Institute for Advanced Computer Science (RIACS) is being established at the Ames Research Center to carry out research in computer science and engineering in areas of potential long-term application to NASA programs.

Research on highly reliable, cost-effective computing focuses on the technology underlying the construction of systems for man-rated flight vehicles. The emphasis is on investigations of fault-tolerant hardware architectures and cost-effective tools and techniques for developing verifiably correct software.

The objective of the research in information management is to exploit technical advances in computers to aid the engineering design and analysis process. The Integrated Program for Aerospace Vehicle Design (IPAD) is continuing research on large-scale design data base management. Techniques to handle basic geometry in a multi-schema (multiview) environment have been developed and implemented and are currently undergoing evaluation.

A major component of the computer science and applications program is to provide state-of-the-art high performance computational resources for aerospace research. ~~Ames~~ Research Center has installed a CRAY 1S-1300 computer with a CDC dual 720 support computer. Lewis Research Center has installed a CRAY 1S-2200 computer utilizing an IBM 370/3033 attached processor for input and output services. These systems are being used for scientific computation in fluid dynamics, chemistry, and thermal and structural analysis.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

The \$5.0 million increase in funding for the computer science and applications research activity is part of an overall internal realignment directed toward applying increased emphasis on critical programs in this area. The additional resources being applied in FY 1983 support priority programs such as the Class VI computer upgrade, a new computer science focus within the research and technology base and the continuation of the IPAD activities.

BASIS OF FY 1984 ESTIMATE:

In FY 1984 the computer science research program will expand efforts in system verification and validation technology for highly reliable systems, and evaluation techniques for managing complexity in large-scale systems. Research in concurrent processing will be initiated, including work in system architectures for parallel processing, programming languages which facilitate concurrency, and a characterization and evaluation of resource management techniques appropriate for operating systems of concurrent machines. The IPAD project will be advancing toward a 1985 establishment of IPAD data base management software on a CDC host computer, including a full geometry capability and limited computer networking. The Finite Element Machine (FEM) architecture will be expanded to a 36 microprocessor configuration, based on the success of an early 4-processor prototype and its successor, the 16-processor machine which will be operational in early 1983.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Propulsion systems research and technology	18 ,616	18,600	16,600	28 ,500

OBJECTIVES AND STATUS:

The objective of the propulsion systems research and technology program is to provide fundamental understanding and generic technology through the verification of computational methods developed under the fluid and thermal physics program and the use of these computational methods to design advanced propulsion components and systems. These technology advances will allow continued future improvements in military and civil aircraft propulsion system efficiency, engine performance, fuel flexibility, reliability, and durability as well as environmental compatibility. The potential of advanced propulsion system concepts is also evaluated within the program. Research is being performed in the areas of turbomachinery, combustion and fuels, propulsion system integration, power transfer, engine systems, controls, and instrumentation. These component and engine system technology advances will lead to major propulsion system improvements in a broad range of military and civil aircraft ranging from small missile and general aviation aircraft to transports, helicopters and high-performance military aircraft.

Major efforts are being made in all of the component areas to acquire detailed data for verification of computational fluid dynamics computer codes. Nonintrusive laser velocimeter data have been obtained for a low aspect ratio fan stage and are being compared to an inviscid three-dimensional Euler code. Laser velocimeter data are also being obtained for three core inlet stages and two controlled diffusion stators. For propellers, laser measurements have been compared to lifting line analysis, and solutions for Euler lifting surface analysis have predicted shock locations agreeing with experimental flow visualization data. The first advanced propeller performance data was obtained at takeoff and climb conditions for comparison with predicted performance. Through use of analysis, turbine cascade flow turning predictions were extended to 75 degrees which is significantly higher than previously possible. Checkout of a new high pressure turbine facility in 1983 will allow creation of an engine environment to correlate cooling data between hot cascade rigs, warm turbine facilities, and the actual engine environment. In combustor research, a multistep kinetic model for soot formation has been developed and reported. Experimental and analytical work is providing data on the effects of broad specification fuels on combustor durability and performance. In inlet research, excellent agreement has been obtained between analysis and sidewall shock

boundary layer interactions. Axisymmetric inlets at angle-of-attack have been analyzed for the first time with a fully viscous analysis. Dynamic simulations of compressor and engine systems in stall have been generated for comparison with experimental results. In controls research, real-time engine simulation has been demonstrated on parallel microprocessors. Research on innovative sensors for digital controls continues with the development of a Fabry-Perot temperature sensor. Basic instrumentation research is directed toward development of high temperature sensors and electronics for engine measurements. Silicon carbide crystals appropriate for high temperature electronic devices have been generated for the first time. Approximate and multi-dimensional analytical computer models are being developed for piston and rotary engines. The approximate rotary engine model will be validated this year. Power transfer research has generated a life and reliability analysis for planetary gear trains. An advanced helicopter transmission has been designed and fabricated which is 24 percent lighter than existing transmissions.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.0 million decrease in the propulsion systems research and technology funding level in FY 1983 is primarily attributable to a decision to place programmatic funding constraints on certain tasks in order to allow for a redirection of resources in support of critical computer science and applications and high-performance aircraft program activities. To accommodate this program rebalancing, the funding level has been reduced in the areas of turbomachinery components, combustion and fuels, and power transfer.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the scope and funding of propulsion system research and technology will be expanded significantly. Additional emphasis will be placed on technology for propulsion system integration and on turbine engine cycle advances to improve performance and survivability.

Turbine engine component research will continue to focus on the verification of component modeling computer analysis and its use for design of advanced configurations. Basic compressor flow measurements by laser doppler velocimeter will be extended to a three-stage rig typical of core inlet stages. Component work will also investigate centrifugal compressors and the scale effects associated with viscous layers and manufacturing limitations. Turbine research will experimentally investigate turbine cooling using the Lewis Research Center's High Pressure Facility for correlation of data with the Center's hot cascade and warm turbine rigs. Analysis of three-dimensional viscous turbine passage flows will also be demonstrated. Propeller research will extend the laser doppler velocimeter data base to off design operation of propellers and comparisons will be made with three-dimensional Euler and potential lifting surface codes. In combustor research, in-house testing will extend the operating pressure and temperature range of fuel property effects

on soot, emissions, radiation, ignition and relight. Research on inlets will acquire the first detailed three-dimensional viscous data for axisymmetric supersonic inlets at angle-of-attack. Data at high subsonic speeds will be acquired for offset diffusers and compared to viscous analysis. Nozzle analysis will be extended to cover supersonic non-axisymmetric configurations. Engine systems research will compare dynamic models for engine systems on stall to high bypass General Electric TF34 data and low bypass Pratt and Whitney PW1130 data to be acquired. Multistage compressor in stall data will be acquired to provide better dynamic component modeling. Internal combustion engine research will demonstrate a high output insulated diesel aircraft cylinder, and a turbocharged direct fuel injection rotary engine with advanced seals. Instrumentation research will develop the first high temperature electronic components using a silicon carbide base and initiate fabrication of prototype high temperature pressure transducers.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Rotorcraft research and technology...	20,175	21,800	23,000	23,300

OBJECTIVE AND STATUS:

The objectives of the rotorcraft research and technology program are to provide analytical bases in the areas of aerodynamics; flight dynamics and control; man-system integration; structures and dynamics; and wind-tunnel, simulation and flight experiments support. Specific objectives include: (1) analysis of unsteady aerodynamics, transonic flow, blade vortex interaction and wake flow; (2) development of handling qualities criteria; (3) development of a technical base of human information transfer in the unique helicopter cockpit environment; (4) prediction of external noise; (5) reduction in dynamic loads and prediction of vehicle response; (6) long-term evaluation of flight service of composite components; and (7) fundamental understanding of helicopter icing mechanisms. These efforts are complemented by portions of the systems technology program in rotorcraft.

During the past year, progress has been achieved in analyses of rotor unsteady aerodynamics. Three-dimensional analyses for transonic flow, which account for wake vortex interaction, have been completed. Experimental comparisons have also been completed. These new analyses have been made available to the five United States helicopter manufacturers. In addition, small-scale/full-scale wind-tunnel data correlation of fuselage drag prediction methods was completed utilizing the Bell Model 222 fuselage configuration. In the area of handling qualities, research support was provided to the Federal Aviation Administration (FAA) and

the Department of Defense (DOD) on flying qualities certification and military specification criteria, respectively. Instrumentation flight decelerating approach experiments were conducted in support of the FAA, and Nap-of-the-Earth (NOE) engine/governor dynamics experiments were conducted on the Vertical Motion Simulator at the Ames Research Center to provide a data base for future military specifications. Human factors research focused on the validation of available techniques to measure pilot workload accurately in the unique helicopter environment. Helicopter noise research received increased emphasis and an acoustic specialists workshop was held to define the state-of-technology and the challenges remaining to achieve a design-for-noise capability. Flight tests were completed using an OH-6 helicopter to explore the vibration reduction potential of higher harmonic control concepts which drive the rotor blade pitch control at high frequencies to nullify rotor vibration forces. The long-term evaluation of composite structural components in various operational environments focused on the return of the initial set of flight components from 206L and S-76 helicopters for laboratory testing at the Langley Research Center. In the area of helicopter icing, a research program was initiated with airfoil testing in the high-speed icing tunnel at the Lewis Research Center to develop ice accretion data as a basis for analytical prediction method development.

CHANGES FROM FY 1983 BUDGET ESTIMATE

The \$1.2 million increase in the rotorcraft research and technology base funding level reflects additional support for both low-speed aerodynamics and noise research, and low-speed simulation and flight system support activity in FY 1983.

BASIS FOR FY 1984 ESTIMATE:

A major effort will be undertaken to couple far-wake prediction calculations to the existing transonic airfoil aerodynamics prediction capability to probe low noise rotor design capability. This effort will also explore the trade-offs available by operating at reduced rotor rotational speed. Also, increased activity in circulation control aerodynamics theory will be carried on in support of the X-Wing rotor development program. Rotorcraft aerodynamics research will also include small-scale rotor tests utilizing a new test,rig for hover tests of rotor/wing interaction.

In the area of flight dynamics and control, increased effort will be focused on a cooperative program with the FAA aimed at building up a data base for the development of tilt rotor certification criteria. In addition, flight and simulation activities will be continued in support of the DOD update of military handling qualities criteria. This validation experiments will be carried out utilizing extensive flight test data available for the UH-60 helicopter. This validation activity will also address piloted simulation utilizing simulated Global Positioning System (GPS) inputs as a navigation link.

Increased emphasis will be given to the subject of the fundamental understanding of helicopter external noise as a base upon which to build new prediction capability. Small-scale model tests will be conducted to investigate tip vortex induced impulsive noise, broad band noise sources and the relationship between small-scale and large-scale noise data. Research on the understanding and control techniques for helicopter interior noise will also continue.

In the area of vibration reduction, flight tests will be completed and data analysis will be carried out in the investigation of active control concepts for vibration reduction. Flight test data from the OH-6 helicopter will be used to assess the benefits of active control techniques. Open-loop flight data is now available and the closed-loop data will be acquired in FY 1983 as a basis for the extensive data analysis and reporting activity.

Rotorcraft structures research will emphasize the investigation of thin gauge composite buckled skin concepts which are a unique aspect of helicopter airframe design. Composite concepts for improved energy absorption and crash safety will also be investigated. Innovative joining and attachment concepts will be explored and curved fuselage frames will be designed, fabricated, and tested to build a design data base. The long-term service evaluation of composites will involve additional static tests of components removed from the field.

Operating problems research will focus on the problems of helicopter icing protection and contingency power requirements. In the area of icing research, the results of icing tunnel tests of helicopter airfoils will be used to investigate the ability to predict the degradation of rotor performance due to ice build-up. This activity will be extended to flight test to determine the extent of correlation between wind-tunnel icing data and actual flight icing build-up and performance degradation. An Army-supplied T700 engine will be extensively instrumented and modified with water injection hardware for testing to provide a data base on the use of water injection for short-term contingency power capability in helicopter turbine engines.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
High-performance aircraft research and technology	29 ,029	35,700	38 ,000	38 ,600

OBJECTIVES AND STATUS:

The objective of the high-performance aircraft research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high speed aircraft and missiles, including powered-lift aircraft with vertical or short takeoff and landing capabilities (V/STOL), supersonic cruise and maneuver aircraft with conventional or short takeoff and landing characteristics, and hypersonic cruise aircraft.

In powered-lift research and technology, emphasis continues on the development and verification of analytical prediction methods essential to development of efficient and effective military V/STOL aircraft. Aerodynamic performance characteristics were obtained from high-speed wind-tunnel tests of several twin-engine, high-speed fighter/attack aircraft concepts which included tandem fan, remote augmentor lift, and augmentor ejector propulsion systems. Promising single engine aircraft concepts resulting from recently completed system studies will also undergo high-speed wind-tunnel testing in FY 1983 to determine their aerodynamic performance characteristics. In flight dynamics, extensive analysis of high angle-of-attack flight characteristics, stall/spin behavior, and improved low-speed combat maneuverability were conducted for a family of advanced fighter aircraft concepts. Piloted simulation studies have investigated control system requirements for integration of thrust vectoring with aerodynamic controls and for utilizing thrust vectoring throughout the flight envelope. In aerodynamics and propulsion integration, NASA cooperative efforts are being pursued with industry on high-performance military airplane wing and leading edge design concepts in combined analytical/experimental programs. During the last year methodology was defined for integrating empennages into single and twin engine fighter aircraft with thrust reversal. Extensive wind-tunnel testing of advanced fighter concepts with integrated non-axisymmetric nozzles is continuing to provide verification of prediction methods and for development of a parametric data base.

High-performance aircraft controls technology studies have been completed and a program is underway to evolve new system architectures for highly integrated airframe and propulsion controls applicable to future high-performance aircraft having strong airframe/propulsion interactions by building upon extensive experience in digital fly-by-wire airframe and digital engine controls.

Essentially all of the selected work carried over following termination of the supersonic cruise research program has been completed. The high speed aircraft structures activities have been redirected in-house at the Langley Research Center to titanium fabrication techniques using superplastic forming and weld brazing processes. The activities in supersonic cruise aerodynamics and configuration development have been directed to military concepts. The axisymmetric inlet configuration with translating centerbodies has been documented over the full operating speed range. Research emphasis has shifted to variable diameter centerbodies, half axisymmetric, and conformal variable geometry inlet concepts.

Work on dual engine high-speed vehicle concepts is continuing with special emphasis on propulsion system, variable geometry nozzle, and two-dimensional inlet integration. Dual-mode (subsonic/supersonic combustion) ramjet development is continuing. Work with liquid hydrogen fuel with subsonic combustion in fixed geometry hardware has now demonstrated the concept of dual-mode operation.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.3 million increase in the funding level for the high-performance aircraft program reflects an internal realignment of research and technology base funding in order to increase emphasis on high-speed powered-lift short-takeoff-and-vertical landing (STOVL), supersonic design concept evaluations, and hypersonic vehicles. This funding change is consistent with the need to expand the level of high-performance research and technology support to meet priority requirements.

BASIS FOR FY 1984 ESTIMATE:

In FY 1984, the powered-lift research and technology effort will initiate wind-tunnel model testing with new propulsion simulators to provide a more realistic simulation of aerodynamic/propulsion interference effects. Wind-tunnel testing will include two single engine STOVL fighter models to define the aerodynamic performance characteristics.

Flight dynamic activities will emphasize three areas of concern to future tactical military aircraft: analyses of nonlinear high altitude, high angle-of-attack flight characteristics, stall departure/spin behavior, and improved high angle-of-attack combat maneuverability. Piloted simulation studies of the integration of thrust vectoring with aerodynamic controls and of thrust vectoring throughout the flight envelope will be applied to advanced short-takeoff-and-landing (STOL) and STOVL concepts.

Aerodynamics and propulsion integration research will emphasize STOL and STOVL, sustained supersonic operation, and long range missile concepts. The vectored-thrust two-dimensional nozzle program will include

analytical efforts addressing internal aerodynamics, heat transfer and materials, and improved hot section testing capability. It will also include tests on full-scale nozzles.

Advanced controls research will include component technology and subsystem interactions. Digital airframe and engine controls for aircraft with vectored-thrust and reduced stability are also under study.

In the area of supersonic cruise, research will concentrate on configuration development and technology trade-off studies for competitive vehicle concepts. Specific areas of interest include arrow and curved leading edge wing configurations, transonic interference effects and high angle-of-attack performance. Structures technology will remain directed at titanium fabrication concepts for high temperature requirements. Construction will be completed on the variable diameter centerbody inlet wind-tunnel model.

Hypersonic vehicle activities are focusing on two applications with concurrent technology development. For the Mach-5 cruise vehicle with the dual engine propulsion system, research activities include variable geometry inlets, variable geometry nozzles, and hot structures for nacelle construction. Build-up of the hypersonic dual-mode scramjet test module will also begin.

Flight research operations support in FY 1984 will include chase operations, airspeed calibration pacer flights, remotely-piloted research vehicle air drops, and flight crew readiness operations. High-speed wind-tunnel operations will continue to generate extensive experimental data for a range of vehicle configurations with emphasis on high-performance military aircraft.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Subsonic aircraft research and technology.	13,538	10,300	7,500	9,000

OBJECTIVES AND STATUS:

The objectives of the subsonic aircraft research and technology program are to provide a broad base of safety oriented technology and to enhance the data base in subsonic configurations and propulsion-airframe integration. The safety research program is organized into the following major categories: (1) aviation meteorology, (2) aviation operations safety technology, and (3) aircraft systems operating efficiency

improvement. Research emphasizes the understanding of aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques thus leading to a reduction in accidents, loss of life and injuries, and **loss** of equipment.

In meteorological research, significant progress has been made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented **F-106** research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds, and turbulence. The test results are providing a basis for establishing design and lightning protection criteria for advanced digital avionics systems and nonmetallic structures. These unique, high quality data are being provided to industry and the Federal Aviation Administration (**FAA**) for use in design and certification standards establishment, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research is progressing in the development of a computer code for the prediction of severe storms and other meteorological hazards. In-flight remote sensing of hazardous clear air turbulence along with the icing research program has formed the basis for cooperative efforts with the Department of Defense to address the alleviation of icing problems.

Advances were made to increase occupant survivability in post-crash fires by breaking the fire chain through the use of advanced materials. Advanced technology materials, such as fire resistant aircraft seat cushions, interior wall panels, and fuselage windows, were demonstrated in full-scale fuselage fire tests. The development of analytical fire modeling to predict aircraft fire characteristics is underway. A highly instrumented full-scale transport crash program was initiated with **FAA** and industry participation to provide actual crash data for the improvement of transport crash survivability. The crash effectiveness of anti-misting kerosene fuel will also be determined.

Landing gear systems research includes ongoing efforts on tire and wheel failures and the resulting consequences of loads transmitted to the landing gear on aircraft control. The results of the brake dynamics studies have been incorporated into piloted anti-skid braking simulations. Expansion and improvement is underway on the Loads Test Track Facility at the Langley Research Center to better match the aircraft, speed and landing systems loads for current and future aircraft weights and speeds.

Propulsion/airframe integration research has initiated wind-tunnel tests to address improved methods for reducing drag associated with engine and nacelle installation. Preliminary wind-tunnel and flight tests to explore the extent and potential for natural laminar flow on a wide range of smaller aircraft have been completed.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.8 million reduction in the subsonic aircraft research and technology funding level reflects the programmatic determination to redirect additional resources in order to meet high priority computer science and applications and high-performance aircraft program activities within the research and technology base. Accordingly, the level of subsonic aircraft research and technology activity has been reduced in materials and structures and aerodynamics systems research.

BASIS FOR FY 1984 ESTIMATES:

In FY 1984 the aviation safety program will focus heavily on severe storms research which will include gaining additional lightning strike data with the **F-106**. Greater emphasis will be placed on low altitude phenomena such as wind shear, heavy rain effects and vortex detection in the airport area. The controlled full-scale crash of a transport aircraft which will occur in late 1984, will provide the understanding of the effectiveness of anti-misting kerosene additives for crash fire suppression. Additional emphasis will be placed on ensuring the most effective determination and applications of runway friction and braking performance data. In-flight data acquisition in real icing conditions will be the basis for validation of the Lewis Research Center's Icing Research Tunnel results.

In configurations and propulsion/airframe integration, principal efforts in 1984 will be focused on laminar flow around nacelles with both analytical and experimental definition of minimum drag configurations. Natural laminar flow has been demonstrated up to Mach 0.8 and at wing sweep angles exceeding 20 degrees. In 1984 concentration will be on the optimization of wing geometry, airfoils, and surface finish to maximize the extent of laminar flow. Further efforts will also be directed toward analytical prediction and experimental verification of aerodynamic and control system approaches to reducing susceptibility to stalls and spins in light aircraft in a joint NASA/FAA/industry activity.

BASIS OF FY 1984 FUNDING REQUIREMENTS:**SYSTEMS TECHNOLOGY PROGRAMS**

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Materials and structures systems					
technology	1,600	---	---	---	RD 12-28
Propulsion systems technology	500	---	---	---	RD 12-28
Avionics and flight control systems					
technology	1,300	---	---	---	RD 12-29
Rotorcraft systems technology.	21,665	20,600	22,300	27,600	RD 12-30
High-performance aircraft systems					
technology.	13,800	14,800	15,000	19,900	RD 12-33
Subsonic aircraft systems					
technology	27,022	---	17,000	5,000	RD 12-35
Advanced propulsion systems					
technology	26,155	---	28,000	---	RD 12-38
Numerical aerodynamic simulation.....	---	---	---	20,000	RD 12-40
 Total.....	 <u>92,042</u>	 <u>35,400</u>	 <u>82,300</u>	 <u>72,500</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Materials and structures systems technology				
Integrated program for aerospace vehicle design (IPAD).....	1,300	---	---	---
Aeroelasticity of turbine engines	<u>300</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.	<u>1,600</u>	<u>---</u>	<u>---</u>	<u>---</u>

OBJECTIVES AND STATUS:

The objectives of the materials and structures systems technology program concentrated research efforts in the materials and structures technology areas which have high payoff for application in the design of future aircraft and engine systems.

The integrated program for aerospace vehicle design achieved a major milestone in FY 1982 with the release of an engineering data management software package for evaluation by industry and NASA. This activity is continuing in the computer science and applications research and technology base program.

The aeroelasticity of turbine engines program was successfully concluded in FY 1982. The results have provided a baseline for a study of forced response in the materials and structures research and technology base program in FY 1983 and beyond.

propulsion systems technology				
Helicopter transmission technology..	500	---	---	---

OBJECTIVES AND STATUS:

The objective of the helicopter transmission technology program was to demonstrate improvements in weight, noise, maintenance, cost and size of helicopter transmissions through application of advanced technology

power transfer components. Hybrid traction drives have been tested to gain understanding of the integration of traction and gear components. Conventional drive systems have been tested with advanced gears, bearings, seals and lubrication systems, showing major improvements in power/weight ratio and life expectancy. Technology efforts in this area are continuing in the propulsion systems research and technology program.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Avionics and flight control systems technology	1,300	---	---	---

OBJECTIVES AND STATUS:

The avionics and flight controls systems technology program had two objectives. The first was to apply fundamental knowledge gained in the research and technology base to demonstrate technology readiness. This was accomplished at the Ames Research Center through the evaluation and improvement of a number of verification and validation tools for digital flight control systems. These tools became the basis of the Federal Aviation Administration's certification procedure for digital flight control systems and were used in the certification of the Boeing 767 aircraft. The second objective was to promote the transfer of advanced systems techniques to the aircraft industry through experimental testing and verification in a realistic environment. This was accomplished using NASA's F-8 digital fly-by-wire aircraft. An example of such an accomplishment in FY 1982 was the evaluation of an advanced control law developed by the Royal Aircraft Establishment, and the demonstration of the superiority of that control law over comparable existing control laws. The elements of the avionics and flight control systems technology program applicable to generic research are now being carried out under the aircraft controls and guidance research and technology program in the research and technology base.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Rotorcraft systems technology				
Guidance and navigation	1,400	1,500	1,500	1,600
Powered-lift technology	300	---	---	---
Rotor systems research aircraft (RSRA)				
flight research/rotors	5,980	5,600	5,000	3,300
Tilt rotor systems technology	2,580	---	---	---
Advanced rotorcraft technology	11,405	13,500	15,800	14,700
Technology for next generation				
rotorcraft.....	---	---	---	8,000
Total	<u>21,665</u>	<u>20,600</u>	<u>22,300</u>	<u>27,600</u>

OBJECTIVES AND STATUS:

The objective of the rotorcraft systems technology program is to provide ground-based and flight research on integrated systems which hold promise for future military and civil rotorcraft concepts. The program covers the broad technology areas of guidance and navigation; flight research on advanced rotor concepts; tilt rotor systems technology; and rotorcraft technology in specific areas of structural dynamics, noise, aeroelasticity, and propulsion systems. The experimental ground-based and flight testing is closely coupled with collocated Army laboratory efforts and complements the research and technology base program activities.

During the past year, the rotorcraft systems technology program included a number of significant accomplishments. In the guidance and navigation area, research focused on the use of airborne radar for remote site guidance in all-weather operations. A special effort was made to more clearly integrate the activities in this area with the related programs within the FAA. Accomplishments included the flight testing of enhanced weather radar concepts over water, participation in Army millimeter radar flight tests, and initial investigation of image enhancement techniques for on-board guidance displays. Baseline Global Positioning System (GPS) flight tests were conducted to explore system errors as a lead-in to work on differential GPS techniques. Initial studies were done to begin an investigation of flight path guidance for noise abatement procedures.

Advanced rotor systems technology activity continued with heavy emphasis on the **RSRA** operational readiness. The compound configuration achieved full operational status for research flight investigations. The helicopter configuration underwent extensive ground calibration and a subsequent flight loads survey. Extensive in-flight noise data and simultaneous rotor airloads data was acquired from an **AH-1G** research helicopter flight program. Noise data were also acquired from the new **AH-64** helicopter. Preliminary design was initiated for a joint **NASA/Army** research rotor system to be flown on the **RSRA**.

The **tilt** rotor proof-of-concept and military suitability program continued. This joint **NASA/Army** program utilizes the two **XV-15 Tilt Rotor Research Aircraft**. One aircraft was used to expand and fully document the flight operational envelope at normal and high gross weight conditions. These flights covered hover, level flight, conversions between hover and high-speed flight, maneuvers, and high altitude test conditions. The second aircraft was utilized in extensive demonstration flights to assess the suitability of the concept for a number of military operational missions including shipboard operations and **Nap-Of-The-Earth** flying.

Advanced rotorcraft technology activity also focused on tasks complementing the research and technology base efforts. A high priority research effort was initiated in response to the increasing need for a valid helicopter noise prediction capability. This research is to be carried out in a joint program with the United States helicopter manufacturers so that the combined resources from **NASA** and industry can be focused on the development of reliable noise prediction methodology. A major accomplishment was achieved in the development of a finite element computer program and associated **CH-47** shake test data acquisition in preparation for a comparison of the predicted and measured dynamic response of a large helicopter air-frame. Another milestone was achieved in the convertible engine systems technology area with the successful completion of the **TF-34** engine modification design review and the initiation of hardware fabrication in preparation for ground testing.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$1.7 million increase in rotorcraft systems technology primarily is the net result of the \$3.0 million increase resulting from the Congressional appropriation increase applied in the following manner. The advanced rotorcraft technology program reflects an increase of **\$2.3** million and an additional \$0.7 million was applied to low-speed simulation and flight systems support now being budgeted in the research and technology base. In addition, an offsetting reduction of \$0.6 million in funding support for loads and structures data acquisition under the **RSRA** flight research/rotors program has been made in order to support other priority program requirements.

BASIS FOR FY 1984 ESTIMATE:

The rotorcraft guidance and navigation activity will emphasize remote site all-weather operations by conducting a series of simulations to explore high resolution radar application for zero-zero landings. Simulations will also focus on implementation of differential GPS concepts prior to flight investigation. Noise abatement flight path guidance will also be explored in simulation to assess the potential benefits of various concepts.

RSRA/rotor systems research will emphasize advanced configuration assessments of a modern four-bladed rotor and preliminary design of an advanced flight research rotor to be tested on the RSRA. Available airloads data from the AH-1G flight program will be analyzed and correlated with available theory and will be used as input to existing noise prediction programs for correlation with measured noise data. Final checkout will be achieved on the RSRA electronic flight control system in preparation for extended flight research activities. Analysis will be completed on data from the static calibration of the active isolation/balance system on the RSRA and simulation of RSRA flight test conditions will be carried out with the new RSRA interchangeable cab with integrated visual systems in order to verify the airworthiness of the research systems.

Advanced rotorcraft technology will focus on initial ground testing of the composite tilt rotor blades. Rotor noise tests will be conducted in small-scale and large-scale to continue research aimed at developing reliable prediction methodology for rotor systems. Structural dynamics research will emphasize the application of optimization techniques to large finite element analyses for the prediction of helicopter airframe vibration levels. Ground tests will begin to establish a data base for convertible engine concepts utilizing the TF-34 engine and research control system.

In order to advance the state of technology on vehicle concepts, an increased effort in advanced tilt rotor technology will be undertaken in the technology for next generation rotorcraft program with emphasis on exploring the means of improving the speed, range, and flying qualities of the tilt rotor class of vehicle. Advanced structural, aerodynamic, propulsion, and control concepts will be investigated. In addition, in a joint program with the Defense Advanced Research Projects Agency an RSRA vehicle will be modified to accept and flight test an X-Wing rotor system. The primary area of interest here is in the utilization of the RSRA unique capabilities to explore the start-stop phase of flight for the X-Wing concept in the speed range of 200 to 300 knots.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
High-performance aircraft systems technology				
High-performance flight research.....	6,200	8,100	9,200	8,700
Highly maneuverable aircraft technology	1,600	1,100	200	---
Turbine engine hot section technology	<u>6,000</u>	<u>5,600</u>	<u>5,600</u>	<u>11,200</u>
Total.....	<u>13,800</u>	<u>14,800</u>	<u>15,000</u>	<u>19,900</u>

OBJECTIVES AND STATUS

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft for military and civil applications. The program objective is accomplished by analysis, ground-based simulations, and wind tunnel experimental research and flight research tests of aircraft as well as development of specific analytical methods for turbine engine durability improvements.

In FY 1982, research began on an integrated digital flight controls/fire control system for an F-16 aircraft as part of a joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) project. In another part of this joint AFTI effort, research on the variable camber mission-adaptive wing concept proceeded with the modifications and instrumentation of the F-111 aircraft on which the flight research will be performed. An extensive evaluation of a NASA conceived aileron-to-rudder interconnect control system on an F-14 aircraft is in the concluding phase of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Significant propulsion system performance and reliability improvements were flight validated by NASA pilots using an F-100 engine powering an F-15 airplane equipped with a digital electronic engine control in a cooperative NASA/Air Force project. In FY 1983 NASA will continue propulsion system improvement flight investigations using the F-15 with an F-100 engine model derivative. Also, during FY 1983, the joint NASA/Defense Advanced Research Projects Agency (DARPA) X-29A forward swept wing flight demonstration program will be conducting extensive NASA wind-tunnel tests, computational analysis, and ground tests in preparation for flight tests beginning in FY 1984.

Design maneuvering and performance points were successfully demonstrated in flight during this year with the highly maneuverable aircraft technology (HiMAT) vehicles. As a result, final assessment is underway to evaluate the benefits of the new technologies in HiMAT applicable to future fighter aircraft. These include **aeroelastically-tailored** graphite-composite wing/canard structures, closely-coupled wing/canard design configurations, and digital flight control systems integrated with greatly reduced vehicle static stability to achieve lower weight and greater maneuverability.

In FY 1983, the turbine engine hot section technology (HOST) program is addressing engine durability with the following developments: a heat transfer computer program will be **completed** and delivered; a thermodynamic engine model code will be developed; test hardware for large-scale thermal radiation testing will be fabricated; a computer program for dilution jet modeling will be completed; a predictive technique for impingement cooling will be developed; data will be obtained for film cooling effects on boundary layer transition and heat transfer, as well as for mapping the duct flaw itself; oxidation modeling for a promising surface coating will be completed; and, various instruments, including dynamic gas temperature sensors, flow viewing systems and a heat **flux** sensor, will be completed and testing begun.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

Funding changes in the high-performance aircraft systems technology budget have been made to augment high-performance flight research, including support of the joint NASA/DARPA X-29A forward swept wing flight demonstration program. The net change is an increase of \$0.2 million. An additional \$1.1 million is provided for high-performance flight research, of which \$0.9 million is the amount which became available from the HiMAT program following decisions to reduce its scope and accelerate its completion.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding level reflects an increased emphasis on high-performance flight research to provide the technology foundation applicable to the development of future high-speed aircraft. The high-performance flight research activity in FY 1984 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will enter the flight test phase during this period. Under the joint NASA/Air Force AETI projects, the F-16 airplane will begin flight evaluations of integrated technologies comprising an automatic maneuvering and attack system, and the F-111 will commence flight envelope expansion and preliminary performance assessment with the mission adaptive wing. The joint NASA/DARPA X-29A forward swept wing flight demonstration program will begin the **proof-of-concept** flight test phase. This program continues development and validation of advanced aeronautical technologies assessed under the recently completed HiMAT program. A flight program will also be initiated with an F-16 aircraft to demonstrate a concept for a novel external stores pylon design, which will isolate or decouple pylon stores dynamics

effects from airplane wing flutter modes, to enable maximum utilization of the fighter aircraft flight envelope when carrying external stores.

The increase in **HOST** funding is for the planned expansion of the **HOST** research effort. The research will concentrate on turbine flow visualization and three-dimensional heat transfer modeling along with the expansion of the effort in thermo-mechanical/structural analysis. Studies will be initiated on life prediction of coatings. The research program on the use of ceramic materials for **long** life turbine engine components will be emphasized.

	1982 <u>Actual</u>	1983		1984 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Subsonic aircraft systems technology				
Energy efficient transport.....	1,500	---	3,000	---
Laminar flow control.....	8,000	---	3,000	---
Advanced transport operating systems.....	8,622	---	5,000	---
Composite primary aircraft structures.....	E, 900	---	6,000	---
Advanced composite structures technology.. ..	---	---	---	<u>5,000</u>
Total.....	<u>27,022</u>	---	<u>17,000</u>	<u>5,000</u>

OBJECTIVES AND STATUS:

The objective of the subsonic aircraft systems technology program is to provide a substantiated base of key technologies, design data and validated design procedures. Individual concepts are examined in the systems context with other interacting components and technologies to define techniques and procedures for obtaining maximum benefit from these applications.

The objective of the energy efficient transport program has been to provide aerodynamic and active control technology for improved efficiency in transport aircraft. Flight tests of an advanced pitch augmentation

system permitting flight with large unstable margins were completed under the FY 1983 program. Also, fabrication of a flight test version of a multi-axis active flight control system was initiated.

The objective of the laminar flow control program has been to provide a proven technology base for the practical achievement of laminar flow under operational flight conditions. During FY 1983, the first wind-tunnel tests of an optimized laminar flow control airfoil showed extremely large reductions in drag. Equipment modifications to permit potential flight tests of leading edge sections of laminar flow systems are being continued in FY 1983 and are on schedule for an early 1984 flight.

The objective of the advanced transport operating systems program has been to provide system and procedural technology for enhanced interfacing of the aircraft and the air traffic control system. The FY 1983 activity includes the following: a major flight activity to develop basic criteria for Microwave Landing System approaches, begun in FY 1982, will be completed in FY 1983; components for major refurbishment and update of the B-737 flight facility are being procured in FY 1983; and the advanced crew station simulator design will be completed in FY 1983.

The objective of the composite primary aircraft structures program has been to provide a technology base for graphite composite material used in secondary and medium primary aircraft structures. Current composite technology efforts are proceeding on schedule and major milestones are being met on lightly loaded, stiffness critical, secondary and medium primary structures. Secondary composite structures are now state-of-the-art and already in airline operational service on the B-767. The FAA certified the B-737 composite horizontal stabilizer medium primary structure in August 1982, and five shipsets of this component will be installed on the product line and will enter flight service evaluation in 1983. The L-1011 vertical stabilizer successfully completed all strength and damage tolerance tests, and small scale elements are approaching 20 years of simulated environment and fatigue testing. Ground tests of the DC-10 vertical stabilizer are in progress and, in addition to the DC-10 flights of this vertical stabilizer, the USAF has indicated interest in installing a similar stabilizer on the KC-10. The program on medium primary structures will be completed with the FY 1983 FAA certification of the DC-10 vertical fin.

The objective of the advanced composite structures technology program is to develop a composite primary airframe structures technology base that achieves the full potential of weight, fuel, and cost savings possible for the design of civil and military transport aircraft in the 1990's. The program's purpose is to establish a composite engineering data base which will permit government and industry management decisions to commit composites to advanced, large aircraft with acceptable cost and risk. Full airframe use of such lighter weight composites can reduce overall aircraft weight and acquisition costs by up to 15 percent, significantly lowering operational costs and extending service usage.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$17.0 million increase in funding for the subsonic aircraft systems technology program in FY 1983 is the result of Congressional direction to continue support of ongoing activities in the following program areas: composite primary aircraft structures, advanced transport operating systems, laminar flow control, and energy efficient transport.

BASIS OF FY 1984 ESTIMATE:

Funding is not included in FY 1984 for continuation of the laminar flow control, composite primary aircraft structures, energy efficient transport or advanced transport operating systems programs.

The FY 1984 budget estimate for the advanced composite structures technology program is based on consideration of the existing state-of-the-art for composite structures and the technology needed to establish the engineering data and confidence required for the application of composite primary structures to large civil and military transport aircraft in the 1990's. This research and technology effort will be initiated in three major areas: (1) wing technology development focused on critical design issues, structural criteria, and certification requirements, (2) fuselage curved panel technology considering biaxial and post-buckled loading, and (3) advanced materials with increased resistance to damage and impact loads. These efforts will provide a basic understanding of composite performance in large airframe structures, and provide design guidance in the development of acceptable configurations and procedures to evaluate limiting structural effects.

In FY 1984, wing structure activity will include the completion of a preliminary design, the establishment of structural configurations, and the initiation of small scale tests. Analytical procedures will be determined and structural criteria defined for thick laminates, fuel containment, and damage tolerance. This research will begin to provide the design engineering data and criteria needed to support future designs of large, heavily loaded composite wing structures.

Technology development for fuselage structures in FY 1984 will focus on establishing design concepts, identifying critical design issues, and determining damage resistant configurations. Additional work will define limits of post-buckling behavior and will extend to larger curved panels under combined pressure and bending loads. These efforts will provide design approaches and engineering data on strength critical, large curved panels and establish design methods and criteria for large, thin pressure sections.

Advanced materials research and technology will concentrate on tougher, more processable systems with increased resistance to flaws and induced damage. New resins will be synthesized to increase strain limits, and the fiber interface will be studied to improve bonding characteristics.

	1982 <u>Actual</u>	1983		1984
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Advanced propulsion systems technology				
Energy efficient engine.. .. .	16,200	---	7,000	---
Advanced turboprop systems.....	9,955	---	15,000	---
General aviation/commuter engine technology.....	---	---	3,000	---
Broad property fuels.....	---	---	3,000	---
Total.....	<u>26,155</u>	<u>---</u>	<u>28,000</u>	<u>---</u>

OBJECTIVES AND STATUS:

The objective of the advanced propulsion systems technology program is to achieve improved performance, lower fuel consumption and reduced noise and emissions in future aircraft engines through the integration of improved propulsion components.

The energy efficient engine program will be completed as scheduled in FY 1983. The final component development and integration phase of the energy efficient engine program will be completed in 1983. The gas generator core test program was successfully conducted, and the integrated core/low spool test is scheduled for the second quarter of FY 1983. The high pressure turbine was run successfully in a warm air rig and further testing of the high pressure compressor is to be completed in 1983. The data continue to support the goal of 15 percent fuel savings with application of these technologies in advanced turbofan engines.

The advanced turboprop systems program achieved encouraging results in 1982 in the areas of installation drag reduction and noise prediction. Wind-tunnel tests of powered scale-model propfans in an under-the-wing installation on modified wings yielded better than predicted drag reductions. Flight tests of scale-model

propfans obtained far-field noise measurements that were lower than analytically predicted. Design and fabrication of large scale (9-foot diameter) propfan blades began in 1983, along with a subscale aeroelastic model of the large-scale propeller. Analytical methods for the design of efficient, low-noise, flutter-free propfan blades are being upgraded and verified. Results obtained to date have increased the potential of achieving 15-20 percent fuel savings relative to an equally advanced turbofan for a variety of civil and military aircraft applications in the Mach 0.7-0.8 cruise regime.

The general aviation/commuter engine technology effort in 1983 is an expansion of small engine component research that is aimed at improving small engine component efficiencies to the levels achieved in large engines. Specifically, analytical design techniques that incorporate the small engine limitations associated with scale, surface finish and Reynolds number will be developed and verified through the use of advanced instrumentation and experimental techniques.

Broad property fuels research within the research and technology base has consisted of research on the physical and combustion properties of future aviation fuels. In 1983 the systems technology program will provide increased emphasis on sub-elements of combustion systems, turbines and fuel systems in order to understand the effects of fuel property variations. The objective is to provide the understanding which will lead to fuel flexible concepts, components, and systems to help aviation adapt to evolving world energy supplies.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$28.0 million increase in funding for the advanced propulsion systems technology program activity in FY 1983 is the result of Congressional direction to continue support of ongoing activities in the following program areas: advanced turboprop systems, general aviation/commuter engine technology, broad property fuels, and the energy efficient engine.

BASIS OF FY 1984 ESTIMATE:

During FY 1984 advanced turbofan technology activity will continue at a lower level of effort in the research and technology base, as will further work on broad property fuels and general aviation/commuter engine technology. Advanced turboprop program activities, funded in prior years, will continue in the research and technology base with long-lead design activities in support of a potential future systems integration/flight research phase to determine large-scale advanced turboprop feasibility.

	1982	1983		1984
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Numerical Aerodynamic Simulation.....	---	---	---	20,000

OBJECTIVES AND STATUS:

The objective of this initiative is to significantly augment the Nation's program in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical aerodynamic simulation. This program will provide new computational capabilities to allow solutions of problems which are currently intractable. The ongoing research in computational aerodynamics will be augmented to provide a pathfinding role in aeronautical research, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of the viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. These results will provide the opportunity to understand the underlying mechanics of turbulence as well as flow separation and reattachment, leading to new concepts for low-drag aircraft and more efficient engines to assure future U.S. aerospace superiority. In addition to basic research, NAS will also play an important future role in preliminary design, configuration refinement and design verification by permitting the accurate prediction of aerodynamic performance, thereby improving the productivity of the research and development process. The program will permit the solution of viscous compressible three-dimensional fluid equations of motion that govern the aerodynamic flow over aircraft and missiles and within components of turbomachines such as compressors and turbine blades and engine inlets and exhaust nozzles. The computational capability will evolve as advanced prototype commercial hardware becomes available, beginning with a computational speed of about 0.3 billion floating point operations per second (GFLOPS) in 1984, increasing to 1 GFLOPS (sustained) and 240 million words of high-speed memory in 1987 and continuing to advance thereafter. It will provide modern and efficient access to about a hundred users nationwide for applications to computational aerodynamics, computational chemistry, and structural analysis as well as other complex analytical problems. Following extensive systems analyses both in-house and under contract, a flexible plan has been prepared for the design and procurement of the system components with phased updates of a commercially available high-speed processor. Simulation studies are being prepared to establish design criteria and provide validation of the new high bandwidth satellite networking system.

BASIS OF FY 1984 ESTIMATE:

Numerical Aerodynamic Simulation is expected to provide important breakthroughs in basic research leading to new understanding of fluid flows, such as the mechanisms of the initiation, propagation, and potential control of turbulence; the ability to calculate internal flows through the complex passages of turbine engines; and the computational power to analytically predict the performance of complete aircraft. NAS pathfinding research will also become increasingly important in the aircraft and turbine engine design process.

First year funding will provide for the cost of an initial high-speed processor with a speed of 0.3 GFLOPS. In addition, procurement of peripheral hardware to serve several generations of high-speed processors will be started and the user-friendly operating system will be evaluated and further developed to meet the needs of succeeding phases of the program. Previously funded studies of cost and technology readiness provide for high confidence in the estimates.

A flexible plan has been prepared for the design and procurement of the system components. In addition to providing the initial high-speed processor (0.3 GFLOPS), the first year funding will enable considerable progress toward the implementation and testing of a user-friendly peripheral system which will serve several generations of high-speed processors and provide for extensive simulations to verify the succeeding phases of the project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

<u>Programs</u>	Budget Plan			
	1983			1984
	1982 <u>Actual</u>	Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	Budget <u>Estimate</u>
Aeronautical research and technology..	264,800	232,000	280,000	300,300
Space research and technology	<u>111,000</u>	<u>123,000</u>	<u>123,000</u>	<u>138,000</u>
<u>Tal.....</u>	<u>375,800</u>	<u>355,000</u>	<u>403,000</u>	<u>438,300</u>

A major component of the computer science and applications program is to provide state-of-the-art high performance computational resources for aerospace research. ~~Ames~~ Research Center has installed a CRAY 1S-1300 computer with a CDC dual 720 support computer. Lewis Research Center has installed a CRAY 1S-2200 computer utilizing an IBM 370/3033 attached processor for input and output services. These systems are being used for scientific computation in fluid dynamics, chemistry, and thermal and structural analysis.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

The \$5.0 million increase in funding for the computer science and applications research activity is part of an overall internal realignment directed toward applying increased emphasis on critical programs in this area. The additional resources being applied in FY 1983 support priority programs such as the Class VI computer upgrade, a new computer science focus within the research and technology base and the continuation of the IPAD activities.

BASIS OF FY 1984 ESTIMATE:

In FY 1984 the computer science research program will expand efforts in system verification and validation technology for highly reliable systems, and evaluation techniques for managing complexity in large-scale systems. Research in concurrent processing will be initiated, including work in system architectures for parallel processing, programming languages which facilitate concurrency, and a characterization and evaluation of resource management techniques appropriate for operating systems of concurrent machines. The IPAD project will be advancing toward a 1985 establishment of IPAD data base management software on a CDC host computer, including a full geometry capability and limited computer networking. The Finite Element Machine (FEM) architecture will be expanded to a 36 microprocessor configuration, based on the success of an early 4-processor prototype and its successor, the 16-processor machine which will be operational in early 1983.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Propulsion systems research and technology	18 ,616	18,600	16,600	28 ,500

OBJECTIVES AND STATUS:

The objective of the propulsion systems research and technology program is to provide fundamental understanding and generic technology through the verification of computational methods developed under the fluid and thermal physics program and the use of these computational methods to design advanced propulsion components and systems. These technology advances will allow continued future improvements in military and civil aircraft propulsion system efficiency, engine performance, fuel flexibility, reliability, and durability as well as environmental compatibility. The potential of advanced propulsion system concepts is also evaluated within the program. Research is being performed in the areas of turbomachinery, combustion and fuels, propulsion system integration, power transfer, engine systems, controls, and instrumentation. These component and engine system technology advances will lead to major propulsion system improvements in a broad range of military and civil aircraft ranging from small missile and general aviation aircraft to transports, helicopters and high-performance military aircraft.

Major efforts are being made in all of the component areas to acquire detailed data for verification of computational fluid dynamics computer codes. Nonintrusive laser velocimeter data have been obtained for a low aspect ratio fan stage and are being compared to an inviscid three-dimensional Euler code. Laser velocimeter data are also being obtained for three core inlet stages and two controlled diffusion stators. For propellers, laser measurements have been compared to lifting line analysis, and solutions for Euler lifting surface analysis have predicted shock locations agreeing with experimental flow visualization data. The first advanced propeller performance data was obtained at takeoff and climb conditions for comparison with predicted performance. Through use of analysis, turbine cascade flow turning predictions were extended to 75 degrees which is significantly higher than previously possible. Checkout of a new high pressure turbine facility in 1983 will allow creation of an engine environment to correlate cooling data between hot cascade rigs, warm turbine facilities, and the actual engine environment. In combustor research, a multistep kinetic model for soot formation has been developed and reported. Experimental and analytical work is providing data on the effects of broad specification fuels on combustor durability and performance. In inlet research, excellent agreement has been obtained between analysis and sidewall shock

boundary layer interactions. Axisymmetric inlets at angle-of-attack have been analyzed for the first time with a fully viscous analysis. Dynamic simulations of compressor and engine systems in stall have been generated for comparison with experimental results. In controls research, real-time engine simulation has been demonstrated on parallel microprocessors. Research on innovative sensors for digital controls continues with the development of a Fabry-Perot temperature sensor. Basic instrumentation research is directed toward development of high temperature sensors and electronics for engine measurements. Silicon carbide crystals appropriate for high temperature electronic devices have been generated for the first time. Approximate and multi-dimensional analytical computer models are being developed for piston and rotary engines. The approximate rotary engine model will be validated this year. Power transfer research has generated a life and reliability analysis for planetary gear trains. An advanced helicopter transmission has been designed and fabricated which is 24 percent lighter than existing transmissions.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.0 million decrease in the propulsion systems research and technology funding level in FY 1983 is primarily attributable to a decision to place programmatic funding constraints on certain tasks in order to allow for a redirection of resources in support of critical computer science and applications and high-performance aircraft program activities. To accommodate this program rebalancing, the funding level has been reduced in the areas of turbomachinery components, combustion and fuels, and power transfer.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the scope and funding of propulsion system research and technology will be expanded significantly. Additional emphasis will be placed on technology for propulsion system integration and on turbine engine cycle advances to improve performance and survivability.

Turbine engine component research will continue to focus on the verification of component modeling computer analysis and its use for design of advanced configurations. Basic compressor flow measurements by laser doppler velocimeter will be extended to a three-stage rig typical of core inlet stages. Component work will also investigate centrifugal compressors and the scale effects associated with viscous layers and manufacturing limitations. Turbine research will experimentally investigate turbine cooling using the Lewis Research Center's High Pressure Facility for correlation of data with the Center's hot cascade and warm turbine rigs. Analysis of three-dimensional viscous turbine passage flows will also be demonstrated. Propeller research will extend the laser doppler velocimeter data base to off design operation of propellers and comparisons will be made with three-dimensional Euler and potential lifting surface codes. In combustor research, in-house testing will extend the operating pressure and temperature range of fuel property effects

on soot, emissions, radiation, ignition and relight. Research on inlets will acquire the first detailed three-dimensional viscous data for axisymmetric supersonic inlets at angle-of-attack. Data at high subsonic speeds will be acquired for offset diffusers and compared to viscous analysis. Nozzle analysis will be extended to cover supersonic non-axisymmetric configurations. Engine systems research will compare dynamic models for engine systems on stall to high bypass General Electric TF34 data and low bypass Pratt and Whitney PW1130 data to be acquired. Multistage compressor in stall data will be acquired to provide better dynamic component modeling. Internal combustion engine research will demonstrate a high output insulated diesel aircraft cylinder, and a turbocharged direct fuel injection rotary engine with advanced seals. Instrumentation research will develop the first high temperature electronic components using a silicon carbide base and initiate fabrication of prototype high temperature pressure transducers.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Rotorcraft research and technology...	20,175	21,800	23,000	23,300

OBJECTIVE AND STATUS:

The objectives of the rotorcraft research and technology program are to provide analytical bases in the areas of aerodynamics; flight dynamics and control; man-system integration; structures and dynamics; and wind-tunnel, simulation and flight experiments support. Specific objectives include: (1) analysis of unsteady aerodynamics, transonic flow, blade vortex interaction and wake flow; (2) development of handling qualities criteria; (3) development of a technical base of human information transfer in the unique helicopter cockpit environment; (4) prediction of external noise; (5) reduction in dynamic loads and prediction of vehicle response; (6) long-term evaluation of flight service of composite components; and (7) fundamental understanding of helicopter icing mechanisms. These efforts are complemented by portions of the systems technology program in rotorcraft.

During the past year, progress has been achieved in analyses of rotor unsteady aerodynamics. Three-dimensional analyses for transonic flow, which account for wake vortex interaction, have been completed. Experimental comparisons have also been completed. These new analyses have been made available to the five United States helicopter manufacturers. In addition, small-scale/full-scale wind-tunnel data correlation of fuselage drag prediction methods was completed utilizing the Bell Model 222 fuselage configuration. In the area of handling qualities, research support was provided to the Federal Aviation Administration (FAA) and

the Department of Defense (DOD) on flying qualities certification and military specification criteria, respectively. Instrumentation flight decelerating approach experiments were conducted in support of the FAA, and Nap-of-the-Earth (NOE) engine/governor dynamics experiments were conducted on the Vertical Motion Simulator at the Ames Research Center to provide a data base for future military specifications. Human factors research focused on the validation of available techniques to measure pilot workload accurately in the unique helicopter environment. Helicopter noise research received increased emphasis and an acoustic specialists workshop was held to define the state-of-technology and the challenges remaining to achieve a design-for-noise capability. Flight tests were completed using an OH-6 helicopter to explore the vibration reduction potential of higher harmonic control concepts which drive the rotor blade pitch control at high frequencies to nullify rotor vibration forces. The long-term evaluation of composite structural components in various operational environments focused on the return of the initial set of flight components from 206L and S-76 helicopters for laboratory testing at the Langley Research Center. In the area of helicopter icing, a research program was initiated with airfoil testing in the high-speed icing tunnel at the Lewis Research Center to develop ice accretion data as a basis for analytical prediction method development.

CHANGES FROM FY 1983 BUDGET ESTIMATE

The \$1.2 million increase in the rotorcraft research and technology base funding level reflects additional support for both low-speed aerodynamics and noise research, and low-speed simulation and flight system support activity in FY 1983.

BASIS FOR FY 1984 ESTIMATE:

A major effort will be undertaken to couple far-wake prediction calculations to the existing transonic airfoil aerodynamics prediction capability to probe low noise rotor design capability. This effort will also explore the trade-offs available by operating at reduced rotor rotational speed. Also, increased activity in circulation control aerodynamics theory will be carried on in support of the X-Wing rotor development program. Rotorcraft aerodynamics research will also include small-scale rotor tests utilizing a new test,rig for hover tests of rotor/wing interaction.

In the area of flight dynamics and control, increased effort will be focused on a cooperative program with the FAA aimed at building up a data base for the development of tilt rotor certification criteria. In addition, flight and simulation activities will be continued in support of the DOD update of military handling qualities criteria. This validation experiments will be carried out utilizing extensive flight test data available for the UH-60 helicopter. This validation activity will also address piloted simulation utilizing simulated Global Positioning System (GPS) inputs as a navigation link.

Increased emphasis will be given to the subject of the fundamental understanding of helicopter external noise as a base upon which to build new prediction capability. Small-scale model tests will be conducted to investigate tip vortex induced impulsive noise, broad band noise sources and the relationship between small-scale and large-scale noise data. Research on the understanding and control techniques for helicopter interior noise will also continue.

In the area of vibration reduction, flight tests will be completed and data analysis will be carried out in the investigation of active control concepts for vibration reduction. Flight test data from the OH-6 helicopter will be used to assess the benefits of active control techniques. Open-loop flight data is now available and the closed-loop data will be acquired in FY 1983 as a basis for the extensive data analysis and reporting activity.

Rotorcraft structures research will emphasize the investigation of thin gauge composite buckled skin concepts which are a unique aspect of helicopter airframe design. Composite concepts for improved energy absorption and crash safety will also be investigated. Innovative joining and attachment concepts will be explored and curved fuselage frames will be designed, fabricated, and tested to build a design data base. The long-term service evaluation of composites will involve additional static tests of components removed from the field.

Operating problems research will focus on the problems of helicopter icing protection and contingency power requirements. In the area of icing research, the results of icing tunnel tests of helicopter airfoils will be used to investigate the ability to predict the degradation of rotor performance due to ice build-up. This activity will be extended to flight test to determine the extent of correlation between wind-tunnel icing data and actual flight icing build-up and performance degradation. An Army-supplied T700 engine will be extensively instrumented and modified with water injection hardware for testing to provide a data base on the use of water injection for short-term contingency power capability in helicopter turbine engines.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
High-performance aircraft research and technology	29 ,029	35,700	38 ,000	38 ,600

OBJECTIVES AND STATUS:

The objective of the high-performance aircraft research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high speed aircraft and missiles, including powered-lift aircraft with vertical or short takeoff and landing capabilities (V/STOL), supersonic cruise and maneuver aircraft with conventional or short takeoff and landing characteristics, and hypersonic cruise aircraft.

In powered-lift research and technology, emphasis continues on the development and verification of analytical prediction methods essential to development of efficient and effective military V/STOL aircraft. Aerodynamic performance characteristics were obtained from high-speed wind-tunnel tests of several twin-engine, high-speed fighter/attack aircraft concepts which included tandem fan, remote augmentor lift, and augmentor ejector propulsion systems. Promising single engine aircraft concepts resulting from recently completed system studies will also undergo high-speed wind-tunnel testing in FY 1983 to determine their aerodynamic performance characteristics. In flight dynamics, extensive analysis of high angle-of-attack flight characteristics, stall/spin behavior, and improved low-speed combat maneuverability were conducted for a family of advanced fighter aircraft concepts. Piloted simulation studies have investigated control system requirements for integration of thrust vectoring with aerodynamic controls and for utilizing thrust vectoring throughout the flight envelope. In aerodynamics and propulsion integration, NASA cooperative efforts are being pursued with industry on high-performance military airplane wing and leading edge design concepts in combined analytical/experimental programs. During the last year methodology was defined for integrating empennages into single and twin engine fighter aircraft with thrust reversal. Extensive wind-tunnel testing of advanced fighter concepts with integrated non-axisymmetric nozzles is continuing to provide verification of prediction methods and for development of a parametric data base.

High-performance aircraft controls technology studies have been completed and a program is underway to evolve new system architectures for highly integrated airframe and propulsion controls applicable to future high-performance aircraft having strong airframe/propulsion interactions by building upon extensive experience in digital fly-by-wire airframe and digital engine controls.

Essentially all of the selected work carried over following termination of the supersonic cruise research program has been completed. The high speed aircraft structures activities have been redirected in-house at the Langley Research Center to titanium fabrication techniques using superplastic forming and weld brazing processes. The activities in supersonic cruise aerodynamics and configuration development have been directed to military concepts. The axisymmetric inlet configuration with translating centerbodies has been documented over the full operating speed range. Research emphasis has shifted to variable diameter centerbodies, half axisymmetric, and conformal variable geometry inlet concepts.

Work on dual engine high-speed vehicle concepts is continuing with special emphasis on propulsion system, variable geometry nozzle, and two-dimensional inlet integration. Dual-mode (subsonic/supersonic combustion) ramjet development is continuing. Work with liquid hydrogen fuel with subsonic combustion in fixed geometry hardware has now demonstrated the concept of dual-mode operation.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.3 million increase in the funding level for the high-performance aircraft program reflects an internal realignment of research and technology base funding in order to increase emphasis on high-speed powered-lift short-takeoff-and-vertical landing (STOVL), supersonic design concept evaluations, and hypersonic vehicles. This funding change is consistent with the need to expand the level of high-performance research and technology support to meet priority requirements.

BASIS FOR FY 1984 ESTIMATE:

In FY 1984, the powered-lift research and technology effort will initiate wind-tunnel model testing with new propulsion simulators to provide a more realistic simulation of aerodynamic/propulsion interference effects. Wind-tunnel testing will include two single engine STOVL fighter models to define the aerodynamic performance characteristics.

Flight dynamic activities will emphasize three areas of concern to future tactical military aircraft: analyses of nonlinear high altitude, high angle-of-attack flight characteristics, stall departure/spin behavior, and improved high angle-of-attack combat maneuverability. Piloted simulation studies of the integration of thrust vectoring with aerodynamic controls and of thrust vectoring throughout the flight envelope will be applied to advanced short-takeoff-and-landing (STOL) and STOVL concepts.

Aerodynamics and propulsion integration research will emphasize STOL and STOVL, sustained supersonic operation, and long range missile concepts. The vectored-thrust two-dimensional nozzle program will include

analytical efforts addressing internal aerodynamics, heat transfer and materials, and improved hot section testing capability. It will also include tests on full-scale nozzles.

Advanced controls research will include component technology and subsystem interactions. Digital airframe and engine controls for aircraft with vectored-thrust and reduced stability are also under study.

In the area of supersonic cruise, research will concentrate on configuration development and technology trade-off studies for competitive vehicle concepts. Specific areas of interest include arrow and curved leading edge wing configurations, transonic interference effects and high angle-of-attack performance. Structures technology will remain directed at titanium fabrication concepts for high temperature requirements. Construction will be completed on the variable diameter centerbody inlet wind-tunnel model.

Hypersonic vehicle activities are focusing on two applications with concurrent technology development. For the Mach-5 cruise vehicle with the dual engine propulsion system, research activities include variable geometry inlets, variable geometry nozzles, and hot structures for nacelle construction. Build-up of the hypersonic dual-mode scramjet test module will also begin.

Flight research operations support in FY 1984 will include chase operations, airspeed calibration pacer flights, remotely-piloted research vehicle air drops, and flight crew readiness operations. High-speed wind-tunnel operations will continue to generate extensive experimental data for a range of vehicle configurations with emphasis on high-performance military aircraft.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Subsonic aircraft research and technology.	13,538	10,300	7,500	9,000

OBJECTIVES AND STATUS:

The objectives of the subsonic aircraft research and technology program are to provide a broad base of safety oriented technology and to enhance the data base in subsonic configurations and propulsion-airframe integration. The safety research program is organized into the following major categories: (1) aviation meteorology, (2) aviation operations safety technology, and (3) aircraft systems operating efficiency

improvement. Research emphasizes the understanding of aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques thus leading to a reduction in accidents, loss of life and injuries, and **loss** of equipment.

In meteorological research, significant progress has been made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented **F-106** research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds, and turbulence. The test results are providing a basis for establishing design and lightning protection criteria for advanced digital avionics systems and nonmetallic structures. These unique, high quality data are being provided to industry and the Federal Aviation Administration (**FAA**) for use in design and certification standards establishment, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research is progressing in the development of a computer code for the prediction of severe storms and other meteorological hazards. In-flight remote sensing of hazardous clear air turbulence along with the icing research program has formed the basis for cooperative efforts with the Department of Defense to address the alleviation of icing problems.

Advances were made to increase occupant survivability in post-crash fires by breaking the fire chain through the use of advanced materials. Advanced technology materials, such as fire resistant aircraft seat cushions, interior wall panels, and fuselage windows, were demonstrated in full-scale fuselage fire tests. The development of analytical fire modeling to predict aircraft fire characteristics is underway. A highly instrumented full-scale transport crash program was initiated with **FAA** and industry participation to provide actual crash data for the improvement of transport crash survivability. The crash effectiveness of anti-misting kerosene fuel will also be determined.

Landing gear systems research includes ongoing efforts on tire and wheel failures and the resulting consequences of loads transmitted to the landing gear on aircraft control. The results of the brake dynamics studies have been incorporated into piloted anti-skid braking simulations. Expansion and improvement is underway on the Loads Test Track Facility at the Langley Research Center to better match the aircraft, speed and landing systems loads for current and future aircraft weights and speeds.

Propulsion/airframe integration research has initiated wind-tunnel tests to address improved methods for reducing drag associated with engine and nacelle installation. Preliminary wind-tunnel and flight tests to explore the extent and potential for natural laminar flow on a wide range of smaller aircraft have been completed.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$2.8 million reduction in the subsonic aircraft research and technology funding level reflects the programmatic determination to redirect additional resources in order to meet high priority computer science and applications and high-performance aircraft program activities within the research and technology base. Accordingly, the level of subsonic aircraft research and technology activity has been reduced in materials and structures and aerodynamics systems research.

BASIS FOR FY 1984 ESTIMATES:

In FY 1984 the aviation safety program will focus heavily on severe storms research which will include gaining additional lightning strike data with the F-106. Greater emphasis will be placed on low altitude phenomena such as wind shear, heavy rain effects and vortex detection in the airport area. The controlled full-scale crash of a transport aircraft which will occur in late 1984, will provide the understanding of the effectiveness of anti-misting kerosene additives for crash fire suppression. Additional emphasis will be placed on ensuring the most effective determination and applications of runway friction and braking performance data. In-flight data acquisition in real icing conditions will be the basis for validation of the Lewis Research Center's Icing Research Tunnel results.

In configurations and propulsion/airframe integration, principal efforts in 1984 will be focused on laminar flow around nacelles with both analytical and experimental definition of minimum drag configurations. Natural laminar flow has been demonstrated up to Mach 0.8 and at wing sweep angles exceeding 20 degrees. In 1984 concentration will be on the optimization of wing geometry, airfoils, and surface finish to maximize the extent of laminar flow. Further efforts will also be directed toward analytical prediction and experimental verification of aerodynamic and control system approaches to reducing susceptibility to stalls and spins in light aircraft in a joint NASA/FAA/industry activity.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1982	1983		1984	
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>	<u>Page</u> <u>Number</u>
Materials and structures systems					
technology	1,600	---	---	---	RD 12-28
Propulsion systems technology.....	500	---	---	---	RD 12-28
Avionics and flight control systems					
technology	1,300	---	---	---	RD 12-29
Rotorcraft systems technology.	21,665	20,600	22,300	27,600	RD 12-30
High-performance aircraft systems					
technology.	13,800	14,800	15,000	19,900	RD 12-33
Subsonic aircraft systems					
technology	27,022	---	17,000	5,000	RD 12-35
Advanced propulsion systems					
technology	26,155	---	28,000	---	RD 12-38
Numerical aerodynamic simulation.....	---	---	---	20,000	RD 12-40
Total.....	92,042	35,400	82,300	72,500	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Materials and structures systems technology				
Integrated program for aerospace vehicle design (IPAD).....	1,300	---	---	---
Aeroelasticity of turbine engines	<u>300</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.	<u>1,600</u>	<u>---</u>	<u>---</u>	<u>---</u>

OBJECTIVES AND STATUS:

The objectives of the materials and structures systems technology program concentrated research efforts in the materials and structures technology areas which have high payoff for application in the design of future aircraft and engine systems.

The integrated program for aerospace vehicle design achieved a major milestone in FY 1982 with the release of an engineering data management software package for evaluation by industry and NASA. This activity is continuing in the computer science and applications research and technology base program.

The aeroelasticity of turbine engines program was successfully concluded in FY 1982. The results have provided a baseline for a study of forced response in the materials and structures research and technology base program in FY 1983 and beyond.

propulsion systems technology				
Helicopter transmission technology..	500	---	---	---

OBJECTIVES AND STATUS:

The objective of the helicopter transmission technology program was to demonstrate improvements in weight, noise, maintenance, cost and size of helicopter transmissions through application of advanced technology

power transfer components. Hybrid traction drives have been tested to gain understanding of the integration of traction and gear components. Conventional drive systems have been tested with advanced gears, bearings, seals and lubrication systems, showing major improvements in power/weight ratio and life expectancy. Technology efforts in this area are continuing in the propulsion systems research and technology program.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Avionics and flight control systems technology	1,300	---	---	---

OBJECTIVES AND STATUS:

The avionics and flight controls systems technology program had two objectives. The first was to apply fundamental knowledge gained in the research and technology base to demonstrate technology readiness. This was accomplished at the Ames Research Center through the evaluation and improvement of a number of verification and validation tools for digital flight control systems. These tools became the basis of the Federal Aviation Administration's certification procedure for digital flight control systems and were used in the certification of the Boeing 767 aircraft. The second objective was to promote the transfer of advanced systems techniques to the aircraft industry through experimental testing and verification in a realistic environment. This was accomplished using NASA's F-8 digital fly-by-wire aircraft. An example of such an accomplishment in FY 1982 was the evaluation of an advanced control law developed by the Royal Aircraft Establishment, and the demonstration of the superiority of that control law over comparable existing control laws. The elements of the avionics and flight control systems technology program applicable to generic research are now being carried out under the aircraft controls and guidance research and technology program in the research and technology base.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Rotorcraft systems technology				
Guidance and navigation	1,400	1,500	1,500	1,600
Powered-lift technology	300	---	---	---
Rotor systems research aircraft (RSRA)				
flight research/rotors	5,980	5,600	5,000	3,300
Tilt rotor systems technology	2,580	---	---	---
Advanced rotorcraft technology	11,405	13,500	15,800	14,700
Technology for next generation				
rotorcraft.....	---	---	---	8,000
Total	<u>21,665</u>	<u>20,600</u>	<u>22,300</u>	<u>27,600</u>

OBJECTIVES AND STATUS:

The objective of the rotorcraft systems technology program is to provide ground-based and flight research on integrated systems which hold promise for future military and civil rotorcraft concepts. The program covers the broad technology areas of guidance and navigation; flight research on advanced rotor concepts; **tilt** rotor systems technology; and rotorcraft technology in specific areas of structural dynamics, noise, aeroelasticity, and propulsion systems. The experimental ground-based and flight testing is closely coupled with collocated Army laboratory efforts and complements the research and technology base program activities.

During the past year, the rotorcraft systems technology program included a number of significant accomplishments. In the guidance and navigation area, research focused on the use of airborne radar for remote site guidance in all-weather operations. A special effort was made to more clearly integrate the activities in this area with the related programs within the **FAA**. Accomplishments included the flight testing of enhanced weather radar concepts over water, participation in Army millimeter radar flight tests, and initial investigation of image enhancement techniques for on-board guidance displays. Baseline Global Positioning System (GPS) flight tests were conducted to explore system errors as a lead-in to work on differential GPS techniques. Initial studies were done to begin an investigation of flight path guidance for noise abatement procedures.

Advanced rotor systems technology activity continued with heavy emphasis on the **RSRA** operational readiness. The compound configuration achieved full operational status for research flight investigations. The helicopter configuration underwent extensive ground calibration and a subsequent flight loads survey. Extensive in-flight noise data and simultaneous rotor airloads data was acquired from an **AH-1G** research helicopter flight program. Noise data were also acquired from the new **AH-64** helicopter. Preliminary design was initiated for a joint **NASA/Army** research rotor system to be flown on the **RSRA**.

The **tilt** rotor proof-of-concept and military suitability program continued. This joint **NASA/Army** program utilizes the two **XV-15 Tilt Rotor Research Aircraft**. One aircraft was used to expand and fully document the flight operational envelope at normal and high gross weight conditions. These flights covered hover, level flight, conversions between hover and high-speed flight, maneuvers, and high altitude test conditions. The second aircraft was utilized in extensive demonstration flights to assess the suitability of the concept for a number of military operational missions including shipboard operations and **Nap-Of-The-Earth** flying.

Advanced rotorcraft technology activity also focused on tasks complementing the research and technology base efforts. A high priority research effort was initiated in response to the increasing need for a valid helicopter noise prediction capability. This research is to be carried out in a joint program with the United States helicopter manufacturers so that the combined resources from **NASA** and industry can be focused on the development of reliable noise prediction methodology. A major accomplishment was achieved in the development of a finite element computer program and associated **CH-47** shake test data acquisition in preparation for a comparison of the predicted and measured dynamic response of a large helicopter air-frame. Another milestone was achieved in the convertible engine systems technology area with the successful completion of the **TF-34** engine modification design review and the initiation of hardware fabrication in preparation for ground testing.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$1.7 million increase in rotorcraft systems technology primarily is the net result of the \$3.0 million increase resulting from the Congressional appropriation increase applied in the following manner. The advanced rotorcraft technology program reflects an increase of **\$2.3** million and an additional \$0.7 million was applied to low-speed simulation and flight systems support now being budgeted in the research and technology base. In addition, an offsetting reduction of \$0.6 million in funding support for loads and structures data acquisition under the **RSRA** flight research/rotors program has been made in order to support other priority program requirements.

BASIS FOR FY 1984 ESTIMATE:

The rotorcraft guidance and navigation activity will emphasize remote site all-weather operations by conducting a series of simulations to explore high resolution radar application for zero-zero landings. Simulations will also focus on implementation of differential GPS concepts prior to flight investigation. Noise abatement flight path guidance will also be explored in simulation to assess the potential benefits of various concepts.

RSRA/rotor systems research will emphasize advanced configuration assessments of a modern four-bladed rotor and preliminary design of an advanced flight research rotor to be tested on the RSRA. Available airloads data from the AH-1G flight program will be analyzed and correlated with available theory and will be used as input to existing noise prediction programs for correlation with measured noise data. Final checkout will be achieved on the RSRA electronic flight control system in preparation for extended flight research activities. Analysis will be completed on data from the static calibration of the active isolation/balance system on the RSRA and simulation of RSRA flight test conditions will be carried out with the new RSRA interchangeable cab with integrated visual systems in order to verify the airworthiness of the research systems.

Advanced rotorcraft technology will focus on initial ground testing of the composite tilt rotor blades. Rotor noise tests will be conducted in small-scale and large-scale to continue research aimed at developing reliable prediction methodology for rotor systems. Structural dynamics research will emphasize the application of optimization techniques to large finite element analyses for the prediction of helicopter airframe vibration levels. Ground tests will begin to establish a data base for convertible engine concepts utilizing the TF-34 engine and research control system.

In order to advance the state of technology on vehicle concepts, an increased effort in advanced tilt rotor technology will be undertaken in the technology for next generation rotorcraft program with emphasis on exploring the means of improving the speed, range, and flying qualities of the tilt rotor class of vehicle. Advanced structural, aerodynamic, propulsion, and control concepts will be investigated. In addition, in a joint program with the Defense Advanced Research Projects Agency an RSRA vehicle will be modified to accept and flight test an X-Wing rotor system. The primary area of interest here is in the utilization of the RSRA unique capabilities to explore the start-stop phase of flight for the X-Wing concept in the speed range of 200 to 300 knots.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
High-performance aircraft systems technology				
High-performance flight research.....	6,200	8,100	9,200	8,700
Highly maneuverable aircraft technology	1,600	1,100	200	---
Turbine engine hot section technology	<u>6,000</u>	<u>5,600</u>	<u>5,600</u>	<u>11,200</u>
Total.....	<u>13,800</u>	<u>14,800</u>	<u>15,000</u>	<u>19,900</u>

OBJECTIVES AND STATUS

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft for military and civil applications. The program objective is accomplished by analysis, ground-based simulations, and wind tunnel experimental research and flight research tests of aircraft as well as development of specific analytical methods for turbine engine durability improvements.

In FY 1982, research began on an integrated digital flight controls/fire control system for an F-16 aircraft as part of a joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) project. In another part of this joint AFTI effort, research on the variable camber mission-adaptive wing concept proceeded with the modifications and instrumentation of the F-111 aircraft on which the flight research will be performed. An extensive evaluation of a NASA conceived aileron-to-rudder interconnect control system on an F-14 aircraft is in the concluding phase of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Significant propulsion system performance and reliability improvements were flight validated by NASA pilots using an F-100 engine powering an F-15 airplane equipped with a digital electronic engine control in a cooperative NASA/Air Force project. In FY 1983 NASA will continue propulsion system improvement flight investigations using the F-15 with an F-100 engine model derivative. Also, during FY 1983, the joint NASA/Defense Advanced Research Projects Agency (DARPA) X-29A forward swept wing flight demonstration program will be conducting extensive NASA wind-tunnel tests, computational analysis, and ground tests in preparation for flight tests beginning in FY 1984.

Design maneuvering and performance points were successfully demonstrated in flight during this year with the highly maneuverable aircraft technology (HiMAT) vehicles. As a result, final assessment is underway to evaluate the benefits of the new technologies in HiMAT applicable to future fighter aircraft. These include **aeroelastically-tailored** graphite-composite wing/canard structures, closely-coupled wing/canard design configurations, and digital flight control systems integrated with greatly reduced vehicle static stability to achieve lower weight and greater maneuverability.

In FY 1983, the turbine engine hot section technology (HOST) program is addressing engine durability with the following developments: a heat transfer computer program will be **completed** and delivered; a thermodynamic engine model code will be developed; test hardware for large-scale thermal radiation testing will be fabricated; a computer program for dilution jet modeling will be completed; a predictive technique for impingement cooling will be developed; data will be obtained for film cooling effects on boundary layer transition and heat transfer, as well as for mapping the duct flaw itself; oxidation modeling for a promising surface coating will be completed; and, various instruments, including dynamic gas temperature sensors, flow viewing systems and a heat **flux** sensor, will be completed and testing begun.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

Funding changes in the high-performance aircraft systems technology budget have been made to augment high-performance flight research, including support of the joint NASA/DARPA X-29A forward swept wing flight demonstration program. The net change is an increase of \$0.2 million. An additional \$1.1 million is provided for high-performance flight research, of which \$0.9 million is the amount which became available from the HiMAT program following decisions to reduce its scope and accelerate its completion.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding level reflects an increased emphasis on high-performance flight research to provide the technology foundation applicable to the development of future high-speed aircraft. The high-performance flight research activity in FY 1984 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will enter the flight test phase during this period. Under the joint NASA/Air Force AETI projects, the F-16 airplane will begin flight evaluations of integrated technologies comprising an automatic maneuvering and attack system, and the F-111 will commence flight envelope expansion and preliminary performance assessment with the mission adaptive wing. The joint NASA/DARPA X-29A forward swept wing flight demonstration program will begin the **proof-of-concept** flight test phase. This program continues development and validation of advanced aeronautical technologies assessed under the recently completed HiMAT program. A flight program will also be initiated with an F-16 aircraft to demonstrate a concept for a novel external stores pylon design, which will isolate or decouple pylon stores dynamics

effects from airplane wing flutter modes, to enable maximum utilization of the fighter aircraft flight envelope when carrying external stores.

The increase in **HOST** funding is for the planned expansion of the **HOST** research effort. The research will concentrate on turbine flow visualization and three-dimensional heat transfer modeling along with the expansion of the effort in thermo-mechanical/structural analysis. Studies will be initiated on life prediction of coatings. The research program on the use of ceramic materials for **long** life turbine engine components will be emphasized.

	1982 <u>Actual</u>	1983		1984 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Subsonic aircraft systems technology				
Energy efficient transport.....	1,500	---	3,000	---
Laminar flow control.....	8,000	---	3,000	---
Advanced transport operating systems.....	8,622	---	5,000	---
Composite primary aircraft structures.....	E, 900	---	6,000	---
Advanced composite structures technology.. ..	---	---	---	<u>5,000</u>
Total.....	<u>27,022</u>	---	<u>17,000</u>	<u>5,000</u>

OBJECTIVES AND STATUS:

The objective of the subsonic aircraft systems technology program is to provide a substantiated base of key technologies, design data and validated design procedures. Individual concepts are examined in the systems context with other interacting components and technologies to define techniques and procedures for obtaining maximum benefit from these applications.

The objective of the energy efficient transport program has been to provide aerodynamic and active control technology for improved efficiency in transport aircraft. Flight tests of an advanced pitch augmentation

system permitting flight with large unstable margins were completed under the FY 1983 program. Also, fabrication of a flight test version of a multi-axis active flight control system was initiated.

The objective of the laminar flow control program has been to provide a proven technology base for the practical achievement of laminar flow under operational flight conditions. During FY 1983, the first wind-tunnel tests of an optimized laminar flow control airfoil showed extremely large reductions in drag. Equipment modifications to permit potential flight tests of leading edge sections of laminar flow systems are being continued in FY 1983 and are on schedule for an early 1984 flight.

The objective of the advanced transport operating systems program has been to provide system and procedural technology for enhanced interfacing of the aircraft and the air traffic control system. The FY 1983 activity includes the following: a major flight activity to develop basic criteria for Microwave Landing System approaches, begun in FY 1982, will be completed in FY 1983; components for major refurbishment and update of the B-737 flight facility are being procured in FY 1983; and the advanced crew station simulator design will be completed in FY 1983.

The objective of the composite primary aircraft structures program has been to provide a technology base for graphite composite material used in secondary and medium primary aircraft structures. Current composite technology efforts are proceeding on schedule and major milestones are being met on lightly loaded, stiffness critical, secondary and medium primary structures. Secondary composite structures are now state-of-the-art and already in airline operational service on the B-767. The FAA certified the B-737 composite horizontal stabilizer medium primary structure in August 1982, and five shipsets of this component will be installed on the product line and will enter flight service evaluation in 1983. The L-1011 vertical stabilizer successfully completed all strength and damage tolerance tests, and small scale elements are approaching 20 years of simulated environment and fatigue testing. Ground tests of the DC-10 vertical stabilizer are in progress and, in addition to the DC-10 flights of this vertical stabilizer, the USAF has indicated interest in installing a similar stabilizer on the KC-10. The program on medium primary structures will be completed with the FY 1983 FAA certification of the DC-10 vertical fin.

The objective of the advanced composite structures technology program is to develop a composite primary airframe structures technology base that achieves the full potential of weight, fuel, and cost savings possible for the design of civil and military transport aircraft in the 1990's. The program's purpose is to establish a composite engineering data base which will permit government and industry management decisions to commit composites to advanced, large aircraft with acceptable cost and risk. Full airframe use of such lighter weight composites can reduce overall aircraft weight and acquisition costs by up to 15 percent, significantly lowering operational costs and extending service usage.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$17.0 million increase in funding for the subsonic aircraft systems technology program in FY 1983 is the result of Congressional direction to continue support of ongoing activities in the following program areas: composite primary aircraft structures, advanced transport operating systems, laminar flow control, and energy efficient transport.

BASIS OF FY 1984 ESTIMATE:

Funding is not included in FY 1984 for continuation of the laminar flow control, composite primary aircraft structures, energy efficient transport or advanced transport operating systems programs.

The FY 1984 budget estimate for the advanced composite structures technology program is based on consideration of the existing state-of-the-art for composite structures and the technology needed to establish the engineering data and confidence required for the application of composite primary structures to large civil and military transport aircraft in the 1990's. This research and technology effort will be initiated in three major areas: (1) wing technology development focused on critical design issues, structural criteria, and certification requirements, (2) fuselage curved panel technology considering biaxial and post-buckled loading, and (3) advanced materials with increased resistance to damage and impact loads. These efforts will provide a basic understanding of composite performance in large airframe structures, and provide design guidance in the development of acceptable configurations and procedures to evaluate limiting structural effects.

In FY 1984, wing structure activity will include the completion of a preliminary design, the establishment of structural configurations, and the initiation of small scale tests. Analytical procedures will be determined and structural criteria defined for thick laminates, fuel containment, and damage tolerance. This research will begin to provide the design engineering data and criteria needed to support future designs of large, heavily loaded composite wing structures.

Technology development for fuselage structures in FY 1984 will focus on establishing design concepts, identifying critical design issues, and determining damage resistant configurations. Additional work will define limits of post-buckling behavior and will extend to larger curved panels under combined pressure and bending loads. These efforts will provide design approaches and engineering data on strength critical, large curved panels and establish design methods and criteria for large, thin pressure sections.

Advanced materials research and technology will concentrate on tougher, more processable systems with increased resistance to flaws and induced damage. New resins will be synthesized to increase strain limits, and the fiber interface will be studied to improve bonding characteristics.

	1982 <u>Actual</u>	1983		1984
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Advanced propulsion systems technology				
Energy efficient engine.. .. .	16,200	---	7,000	---
Advanced turboprop systems.....	9,955	---	15,000	---
General aviation/commuter engine technology.....	---	---	3,000	---
Broad property fuels.....	---	---	3,000	---
Total.....	<u>26,155</u>	<u>---</u>	<u>28,000</u>	<u>---</u>

OBJECTIVES AND STATUS:

The objective of the advanced propulsion systems technology program is to achieve improved performance, lower fuel consumption and reduced noise and emissions in future aircraft engines through the integration of improved propulsion components.

The energy efficient engine program will be completed as scheduled in FY 1983. The final component development and integration phase of the energy efficient engine program will be completed in 1983. The gas generator core test program was successfully conducted, and the integrated core/low spool test is scheduled for the second quarter of FY 1983. The high pressure turbine was run successfully in a warm air rig and further testing of the high pressure compressor is to be completed in 1983. The data continue to support the goal of 15 percent fuel savings with application of these technologies in advanced turbofan engines.

The advanced turboprop systems program achieved encouraging results in 1982 in the areas of installation drag reduction and noise prediction. Wind-tunnel tests of powered scale-model propfans in an under-the-wing installation on modified wings yielded better than predicted drag reductions. Flight tests of scale-model

propfans obtained far-field noise measurements that were lower than analytically predicted. Design and fabrication of large scale (9-foot diameter) propfan blades began in 1983, along with a subscale aeroelastic model of the large-scale propeller. Analytical methods for the design of efficient, low-noise, flutter-free propfan blades are being upgraded and verified. Results obtained to date have increased the potential of achieving 15-20 percent fuel savings relative to an equally advanced turbofan for a variety of civil and military aircraft applications in the Mach 0.7-0.8 cruise regime.

The general aviation/commuter engine technology effort in 1983 is an expansion of small engine component research that is aimed at improving small engine component efficiencies to the levels achieved in large engines. Specifically, analytical design techniques that incorporate the small engine limitations associated with scale, surface finish and Reynolds number will be developed and verified through the use of advanced instrumentation and experimental techniques.

Broad property fuels research within the research and technology base has consisted of research on the physical and combustion properties of future aviation fuels. In 1983 the systems technology program will provide increased emphasis on sub-elements of combustion systems, turbines and fuel systems in order to understand the effects of fuel property variations. The objective is to provide the understanding which will lead to fuel flexible concepts, components, and systems to help aviation adapt to evolving world energy supplies.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$28.0 million increase in funding for the advanced propulsion systems technology program activity in FY 1983 is the result of Congressional direction to continue support of ongoing activities in the following program areas: advanced turboprop systems, general aviation/commuter engine technology, broad property fuels, and the energy efficient engine.

BASIS OF FY 1984 ESTIMATE:

During FY 1984 advanced turbofan technology activity will continue at a lower level of effort in the research and technology base, as will further work on broad property fuels and general aviation/commuter engine technology. Advanced turboprop program activities, funded in prior years, will continue in the research and technology base with long-lead design activities in support of a potential future systems integration/flight research phase to determine large-scale advanced turboprop feasibility.

	1982	1983		1984
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Numerical Aerodynamic Simulation.....	---	---	---	20,000

OBJECTIVES AND STATUS:

The objective of this initiative is to significantly augment the Nation's program in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical aerodynamic simulation. This program will provide new computational capabilities to allow solutions of problems which are currently intractable. The ongoing research in computational aerodynamics will be augmented to provide a pathfinding role in aeronautical research, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of the viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. These results will provide the opportunity to understand the underlying mechanics of turbulence as well as flow separation and reattachment, leading to new concepts for low-drag aircraft and more efficient engines to assure future U.S. aerospace superiority. In addition to basic research, NAS will also play an important future role in preliminary design, configuration refinement and design verification by permitting the accurate prediction of aerodynamic performance, thereby improving the productivity of the research and development process. The program will permit the solution of viscous compressible three-dimensional fluid equations of motion that govern the aerodynamic flow over aircraft and missiles and within components of turbomachines such as compressors and turbine blades and engine inlets and exhaust nozzles. The computational capability will evolve as advanced prototype commercial hardware becomes available, beginning with a computational speed of about 0.3 billion floating point operations per second (GFLOPS) in 1984, increasing to 1 GFLOPS (sustained) and 240 million words of high-speed memory in 1987 and continuing to advance thereafter. It will provide modern and efficient access to about a hundred users nationwide for applications to computational aerodynamics, computational chemistry, and structural analysis as well as other complex analytical problems. Following extensive systems analyses both in-house and under contract, a flexible plan has been prepared for the design and procurement of the system components with phased updates of a commercially available high-speed processor. Simulation studies are being prepared to establish design criteria and provide validation of the new high bandwidth satellite networking system.

BASIS OF FY 1984 ESTIMATE:

Numerical Aerodynamic Simulation is expected to provide important breakthroughs in basic research leading to new understanding of fluid flows, such as the mechanisms of the initiation, propagation, and potential control of turbulence; the ability to calculate internal flows through the complex passages of turbine engines; and the computational power to analytically predict the performance of complete aircraft. NAS pathfinding research will also become increasingly important in the aircraft and turbine engine design process.

First year funding will provide for the cost of an initial high-speed processor with a speed of 0.3 GFLOPS. In addition, procurement of peripheral hardware to serve several generations of high-speed processors will be started and the user-friendly operating system will be evaluated and further developed to meet the needs of succeeding phases of the program. Previously funded studies of cost and technology readiness provide for high confidence in the estimates.

A flexible plan has been prepared for the design and procurement of the system components. In addition to providing the initial high-speed processor (0.3 GFLOPS), the first year funding will enable considerable progress toward the implementation and testing of a user-friendly peripheral system which will serve several generations of high-speed processors and provide for extensive simulations to verify the succeeding phases of the project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1984 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

<u>Programs</u>	Budget Plan			<u>1984 Budget Estimate</u>	
	<u>1982 Actual</u>	<u>1983</u>			
		<u>Budget Estimate</u> (Thousands of	<u>Current Estimate</u> Dollars)		
Aeronautical research and technology..	264,800	232,000	280,000	300,300	
Space research and technology	<u>111,000</u>	<u>123,000</u>	<u>123,000</u>	<u>138,000</u>	
<u>Tal.....</u>	<u>375,800</u>	<u>355,000</u>	<u>403,000</u>	<u>438,300</u>	

SPACE
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		Estimate	Estimate	Estimate	
		(Thousands of	Dollars)		
Research and technology base.....	104,646	115,600	115,100	126,200	RD 13-4
Systems technology programs.....	3,354	4,400	4,900	7,200	RD 13-28
Standards and practices	<u>3,000</u>	<u>3,000</u>	<u>3,000</u>	<u>4,600</u>	RD 13-30
Total.....	<u>111,000</u>	<u>123,000</u>	<u>123,000</u>	<u>138,000</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	8,400	9,700	13,000	14,500	
Kennedy Space Center.....	100	---	150	300	
Marshall Space Flight Center.....	10,900	14,400	13,000	14,600	
Goddard Space Flight Center.....	9,800	10,600	10,150	10,600	
Jet Propulsion Laboratory	22,000	23,000	22,000	23,500	
Ames Research Center.....	10,800	10,700	10,000	11,500	
Langley Research Center.....	25,000	28,300	28,000	30,500	
Lewis Research Center.....	21,000	22,100	22,000	27,500	
Headquarters.....	<u>3,000</u>	<u>4,200</u>	<u>4,700</u>	<u>5,000</u>	
Total.....	<u>111,000</u>	<u>123,000</u>	<u>123,000</u>	<u>138,000</u>	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

<u>Old Structure</u>	SPACE	R&T Base	Aerothermo- dynamics	Chemical Propulsion	Materials & Structures	Electronics & Automation	Space Power & Electronic Propulsion	Multi- disciplinary	Information Systems	S/C Systems	Transportation Systems	Systems Technology Programs	S/C Systems Technology	Spacelab P/L's	LDEF	IAPS	STANDARDS & PRACTICES
	<u>123.0</u>	<u>115.6</u>	8.8	15.5	15.1	9.5	20.0	3.5	24.0	10.4	8.8	<u>4.4</u>	4.4	(1.4)	2.3	(0.5)	<u>3.0</u>
<u>New Structure</u>																	
<u>SPACE</u>	<u>123.0</u>																
<u>R&T Base</u>	<u>115.6</u>	1															
Fluid & Thermal Physics	8.8		8.8														
Materials & Structures	16.8				15.1		0.2			15							
Computer Science & Electronics	15.6					9.5			6.1								
Space Energy Conversion	19.8						19.8										
Multidisciplinary	3.5							3.5									
Controls & Human Factors	1.5									1.5							
Space Data & Communications	17.9								1.9								
Chemical Propulsion	15.4			15.4													
Spacecraft Systems	4.1									4.1							
Transportation Systems	8.3										8.3						
Platform Systems	3.9			0.1						3.3	0.5						
<u>Systems Technology Programs</u>	<u>4.4</u>											<u>4.4</u>					
<u>Spacecraft Systems Technology</u>	<u>4.4</u>												4.4				
Space Flight Experiments	1.4													1.4			
Long-Duration Exposure Facility	2.3														2.3		
Ion Auxiliary Propulsion System	0.7															0.7	
<u>STANDARDS & PRACTICES</u>	<u>3.0</u>																<u>3.0</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The overall objective of the space research and technology program is to advance the technology base in support of NASA's role as an effective, productive, and long-term contributor to the continued preeminence of the Nation in space. A timely investment in research and technology is essential to support and promote rapidly expanding civil, military, and commercial space interests. In planning the space technology program, the Office of Aeronautics and Space Technology (OAST) consults extensively with other NASA program offices, the Department of Defense, and industry in order to identify and anticipate technology needs. Systems analyses and trade-off studies are also conducted to identify high payoff technologies that will enable future space missions. Research and technology development evolves from concept to laboratory, then to proof-of-concept testing on ground or in space and eventually to program application, in a long-term process of incremental progress along both planned and unexpected opportunity paths.

The space research and technology program is committed to: (1) providing a base of proven technology supporting future national programs in the conception and design of advanced spacecraft; (2) continuing development of the technology foundation for improving low-cost access to space through Shuttle enhancements and orbital transfer concepts; (3) supporting activities related to a more permanent human presence in space by focusing technology; (4) supporting the projected long-term needs of military and commercial use of space.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The FY 1983 estimate remains the same in total, although a minor adjustment has been made between the two major program elements.

Within the space research and technology base, an internal program rebalancing was executed in order to place increased emphasis on continuing priority programs including controls, human factors, and crew and life support technology. This realignment of resources, with a net reduction of \$0.5 million, was accomplished by instituting modest reductions in the level of effort planned in FY 1983 on a wide range of research and technology base disciplines and programs.

In the systems technology area, the \$0.5 million increase in funding reflects a programmatic decision to place additional emphasis on high priority Spacelab payloads flight experiment activity in FY 1983.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 research and technology program will be directed toward maintaining a strong research and technology base within the discipline areas of fluid and thermal physics, materials and structures, computer science and electronics, communications and data systems, space energy conversion, controls and human factors, and chemical propulsion. While a portion of the disciplinary program will be directed toward broadly generic or basic goals, many of the program elements provide extended and often enabling capabilities for each of three classes of space systems: spacecraft, space transportation, and space station.

The following high priority technology goals have been emphasized to identify and develop technology options to meet advanced requirements for these future space systems: provide new materials and concepts for orbiter thermal protection; advance the technologies to enable longer-life, reusable engines; provide the technology for orbital transfer vehicle propulsion and tankage; evolve the capability for high capacity electrical power generation, storage, and distribution systems; provide the technology of satellite communications through research in electronic components, space and ground systems, and propagation phenomena; develop enabling technology for large deployable RF antenna systems; generate the technology base for teleoperator and autonomous space systems; improve space information management through smart sensors, onboard data processors, software, systems architecture, and ground systems; generate the technology base in computer science for aerospace applications; develop computational fluid dynamics techniques for application to entry body and rocket engine design; advance the technologies to fully support and exploit human capabilities in space; establish feasibility of advanced sensor concepts; and advance the technology of distributed, adaptive controls for large space systems. Systems-level studies conducted within the research and technology base will continue to focus the discipline and system research and technology activities in directions which will lead to maximum benefits from available resources.

BASIS OF FY 1984 FUNDING REQUIREMENTS -**RESEARCH AND TECHNOLOGY BASE**

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>1984</u> <u>Budget</u> <u>Estimate</u>	<u>Page</u> <u>Number</u>
Fluid and thermal physics research and technology.....	7,894	8,800	8,500	8,800	RD 13-5
Materials and structures research and technology	14,565	16,800	14,700	15,700	RD 13-7
Computer science and electronics research and technology.....	14,130	15,600	15,700	16,300	RD 13-9
Space energy conversion research and technology	18,081	19,800	17,400	18,000	RD 13-12
Multidisciplinary research.....	2,361	3,500	2,100	1,000	RD 13-14
Controls and human factors research and technology.....	2,964	1,500	6,800	7,600	RD 13-15
Space data and communication research and technology	16,902	17,900	18,100	19,300	RD 13-16
Chemical propulsion research and technology	12,956	15,400	15,400	15,700	RD 13-18
Spacecraft systems research and technology	5,071	4,100	3,500	3,700	RD 13-20
Transportation systems research and technology	7,073	8,300	7,800	8,000	RD 13-22
Platform systems research and technology	<u>2,649</u>	<u>3,900</u>	<u>5,100</u>	<u>12,100</u>	RD 13-25
Total.....	<u>104,646</u>	<u>115,600</u>	<u>115,100</u>	<u>126,200</u>	

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Fluid and thermal physics research and technology.. .. .	7,a94	8,800	8,500	8,800

OBJECTIVES AND STATUS:

The objectives of the fluid and thermal physics research and technology program are to: (1) develop validated, experimental and computational techniques for predicting flowfields for a broad range of arbitrary aerospace vehicle configurations; (2) improve techniques for predicting aerodynamic and aerothermodynamic characteristics of vehicle concepts in the continuum-to-rarefied flow regimes; and (3) provide the experimental technology required for aerodynamic and aerothermodynamic testing. Improved techniques for predicting the capability and response of future aerospace vehicles in the various flow regimes, including ascent to orbit, low-earth orbit, and entry, will provide increased confidence needed for maximum use of the performance and payload potential of those systems.

The aerothermodynamic heat-shield analysis for the Galileo probe has been completed, and entry gas dynamics research has been redirected toward studies of vehicle flowfields in the continuum-through-rarefield portions of the Earth's atmosphere. Initial flowfield analyses have been conducted on several future transportation concepts designed to use high-altitude aero-assist techniques in order to minimize propulsion system requirements. Analyses of the aerodynamic and aerothermodynamic characteristics of aero-assisted orbital-transfer and earth-to-orbit vehicle concepts, plus preliminary studies of aero-maneuvering orbit-on-demand vehicle concepts, are in progress.

Since continuum theory is invalid in transitional and rarefied flow, a probabilistic treatment of fundamental Newtonian theory has been developed to provide benchmark predictions of the orbiter jet-thruster flowfield patterns in low-earth orbit. This technique is being extended to predict the drag of space platform configurations, plume flowfields and contamination patterns, and flowfield interactions for rendezvousing vehicles in low-earth orbit.

Current orbiter instrumentation and orbiter experiments are providing the important research-quality flight data needed to evaluate and improve the computational and ground-based experimental methods. Analyses of the flight data have provided new information on the entry environment, flow transition, surface

catalysis , tile-gap heating, and other important phenomena. In addition , unexpected orbiter aerodynamic performance spurred a re-evaluation of the prediction methods for control-surface effectiveness in both the transonic and hypersonic speed regimes .

An important new area of emphasis is characterizing and quantifying the aerothermal loads caused by flow interactions with typical surface irregularities of thermostructural systems. A data base is being developed at simulated, high-energy entry conditions through benchmark experiments on large- to full-scale surface gaps, bowed surfaces, protuberances, fuselage-wing junctions, wing-elevon coves, and other surface irregularities. These benchmark data are being used to validate three-dimensional flowfield computational predictions of peak-heating and pressure-loading magnitudes and locations for complex aerospace configurations.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

A decrease of \$0.3 million reflects a modest reduction in turbulence modeling research in FY 1983 in order to support other high priority space research and technology requirements.

BASIS OF FY 1984 ESTIMATE:

In FY 1984, the research program will emphasize expanding the experimental data base for improved aerospace vehicle design capability and, also, for development and application of **experimentally-validated** computational flowfield prediction techniques. These efforts will be focused on improving future space transportation systems by providing the aerodynamic and aerothermodynamic technology to support more efficient thermostructural systems, enhanced overall aerodynamic performance with emphasis on high-altitude maneuvering capability, and increased engine lifetimes through improved internal aerothermodynamic performance .

Orbit-on-demand vehicles will require substantial improvements in design over current space transportation systems,, including: significantly improved propulsion capability; advanced and reusable thermostructural systems; and sophisticated maneuvering capability throughout the atmosphere. The program will focus on developing the aerodynamic and aerothermodynamic performance capability to meet these requirements for a control-configured space transportation system design concept having rapid response, limited payload capability, and operational flexibility.

Aerodynamic performance and heat transfer requirements will be experimentally evaluated for aeroassisted orbital transfer vehicle concepts with varying lift-to-drag ratios. In addition, three-dimensional

flowfield computational techniques will be developed and evaluated in order to assess thermal protection system requirements and control surface effectiveness through the predicted trajectories.

The research program will also be directed toward prediction techniques for computing the drag of space platforms in low-earth orbit, initially including component shadowing effects for simple configurations and subsequently including complete, complex configurations. The Monte Carlo technique will be used to perform a probabilistic analysis of the molecular interactions in the very rarefied environment at orbital altitudes. This same technique will also be applied, for benchmark cases, to prediction of the flowfield patterns produced by the Space Shuttle propulsion system plumes and their interaction during rendezvous with a space platform.

		1982	1983		1984
		<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Materials and structures					
research and technology....	14 ,565	16,800	14 ,700	15 ,700

OBJECTIVES AND STATUS:

The objectives of the materials and structures research and technology program are to provide the performance, efficiency, durability, and economy required for large area space structures, antennas and space platforms, advanced space transportation systems, orbiting spacecraft, planetary probes, and Shuttle payloads. Major technical areas of emphasis in materials include basic understanding of advanced materials; development of computational chemistry methodology; characterization and understanding of long duration environmental effects of space on materials; and development of ceramic, metallic, and advanced carbon-carbon thermal protection systems. Structures technology is directed toward development of advanced truss structural concepts, reliable methods for deployment/erection of space structures, new concepts for advanced Shuttle and orbital transfer vehicles, and efficient analytical methods for design and evaluation of advanced space structures. Research includes the development of Shuttle payload dynamics and acoustic analysis methods, integrated structures/thermal/controls analysis and optimization techniques, and efficient methods for nonlinear structural analysis.

During the past year the mechanisms and kinetics of the chemical reactions that occur during the cure of epoxy composites were determined, greatly expediting development of techniques to control the processing and

production of uniform, high quality composites. Another major achievement was the invention of a fastener for joining carbon-carbon components in a hot structure which accommodates differential thermal expansion without generating high failure level stresses in either component. Computational fluid dynamics techniques were used for the first time to describe aerothermal loads and pressure, and heating distribution over the surface of thermal protection systems. This capability provides a basis for future protuberance work. With the completion of the Space Environmental Effects Facility, it is now possible to expose candidate materials to all of the space environmental factors at the same time, thus identifying and characterizing synergistic effects. A continuous **400** hour run has demonstrated that there are differences in effects due to radiation dosage rates. Using data recorded in the first three Shuttle orbiter flights, acoustic model predictions have been validated with actual payload bay flight measurements. A computer model has been developed that provides for simultaneous optimization of the trajectory, the structure, and the thermal protection system of a reusable space vehicle to minimize the total weight of the system. A segment of a Shuttle aft body flap made of graphite polyimide has successfully passed all mechanical, thermal, and acoustic tests required for qualification for space flight. Furthermore, the feasibility of directly bonding thermal protection tile to a structure has been demonstrated in simulated flight tests. The combination of the two achievements provides a new structural option for lighter weight space transportation vehicles.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The reduction of \$2.1 million primarily reflects a reduction in research on space durable materials, advanced thermal protection systems, advanced space structures, and materials science. These funds were realigned within the space research and technology base in order to support increased program activities in the areas of controls, human factors, and crew and life support research.

BASIS OF FY 1984 ESTIMATES:

A major research effort is directed at determining the durability of polymeric materials in space, including structural composites, thermal control coatings, films, adhesives, and seals. The emphasis is on identification of damage mechanisms and the development of methodology for accelerated tests to predict long-term performance. Research will focus on identifying stress and developing structural materials that fulfill dimensional stability requirements of large space antennas and space stations. Basic research in the fundamentals of tribology (friction and wear) of bearing systems and long-life space environment lubricants and seals will focus on providing the technology for advances in future space transportation systems. Although intermetallic compounds are presently very brittle, research will be directed toward solutions in order to realize significant performance advantages in advanced turbopumps for the Space Shuttle main engine (SSME). Thermal protection concepts and materials will be evaluated for the protection

of reentry vehicles. A better understanding of fundamental material surface behavior through the application of computational chemistry will continue to be a focus in the program.

In FY 1984, research on truss structural concepts for deployable and erectable space systems and the identification of design and qualification procedures required to meet possible future mission requirements will be completed and evaluation procedures initiated. Simultaneous and sequential deployment concepts will be evaluated and tested for potential application to space station configurations. In the area of integrated analysis and synthesis methods, emphasis will be on improved thermostructural modeling and analysis methods to include thermal radiation and convection effects on structural response. Also, research will focus on the development of optimization methods applicable to space vehicle design for lightest weight and/or cost.

Both analytical and experimental research will be conducted on non-linear behavior of very flexible structures including definition of the interaction between structures, sensors, and controls; active and passive damping effects; and integrated thermal-structural analysis. Payload analysis methods will focus on the adaptation of predictive methods to include coupled Shuttle loads and vibroacoustic response.

The high temperature structures effort will stress the development of the enabling technology for thermal management including research and testing on metallic and advanced carbon-carbon structures for Earth entry vehicles.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Computer science and electronics research and technology.. .. .	14,130	15,600	15,700	16,300

OBJECTIVES AND STATUS:

The objective of the computer science and electronics program is to provide advanced concepts, techniques, system architectures, hardware components, algorithms, and software for space information systems. The program contains disciplinary activities in: electronics, sensor systems, computer science, and automation. Research in electronics is directed at new lasing media and detection methods, and developing new concepts in optical and solid-state technology. Sensor research is focused on extending the

i

capabilities of active and passive sensor systems in terms of spectral range, sensitivity, and resolution. The computer science discipline strives to improve fundamental knowledge of computing principles and advance the state of computational technology in aerospace applications such as fault-tolerant architectures and very high speed processing. Automation research will develop the theoretical and technological base needed to increase the productivity and effectiveness of future operations in space.

In electronics research, advances have been made in ultraviolet excimer lasers and superconducting **insulating-superconducting** devices for new applications to sense the submillimeter portion of the electromagnetic spectrum. New electronic devices that may have revolutionary solid state properties are being experimentally fabricated by means of a technique called molecular beam epitaxy (MBE). The MBE technique allows new electronic devices to be fabricated from single molecule layers. The microscopic properties of the silicon-silicon dioxide interface, and its role in the degradation of device properties subject to space radiation effects has been connected to the angle of the silicon-oxygen band near and at the interface. The effect of this angle on the fabrication process is currently under investigation.

The sensors research program completed fabrication and successfully tested a proof-of-concept model of a 3x3 x-ray imaging array detector. In support of future NASA low-temperature sensor applications, a mechanical cryogenic cooler has been successfully tested with a 5 watt cooling load and a temperature of 70°K. The design of a slot-array antenna for employment in a multi-frequency, multi-polarization synthetic aperture radar system has been completed, and a submillimeter gas wave laser pumped by a CO₂ laser with a unique folded optical system has shown preliminary success in actual observation of galactic environments from a ground-based telescope.

The computer science research program is being initiated in FY 1983. The resulting program focuses on three theme areas: concurrent processing; highly reliable, cost-effective computing; and scientific information management. Concurrent processing research is addressing system architectures and algorithms for **computationally-intensive** problems in aerospace research, such as computational fluid dynamics and image processing. Research on highly reliable, cost-effective computing is focusing on the technology underlying the construction of systems for long-duration unattended space missions and man-rated flight vehicles. The emphasis is on investigations of fault-tolerant hardware architectures and cost-effective tools and techniques for developing verifiably correct software. NASA is presently accumulating approximately ten billion words of scientific space-derived data per day, with expectations of a hundred-fold growth over the next decade. Research is required for the management and distribution of these data to an active scientific community.

In automation research, a computer program called DEVISER was successfully demonstrated in the laboratory to automatically plan and sequence Voyager spacecraft operations during a simulated encounter with Jupiter. The Voyager and Galileo projects have since committed to use DEVISER operationally for science observation planning. The initial version of a Teleoperator and Robotics System Simulator (TRSS) became operational and a study of display and control modes with varying sensor feedback time delays was completed. Research in real-time computer vision for robot control produced a breadboard system capable of tracking three-dimensional objects at a rate of 3 Hertz.

CHANGES FROM FY 1983 BUDGET:

The increase of \$0.1 million reflects additional resources support for automation and computer science activities.

BASIS OF FY 1984 ESTIMATE:

The electronics research and technology program will continue to explore and develop new data and signal processing techniques employing new and different physical mechanisms. Feasibility demonstrations of advanced optical processing devices will be conducted including the liquid crystal light valve and integrated acoustic-optical receivers for applications to real-time smart sensors and synthetic aperture radar processing.

The sensor systems research and technology will focus on the development of components for the submillimeter frequency region of the electromagnetic spectrum, with emphasis on mixers, local oscillators, and meshes. Large arrays using extrinsic silicon for astronomical purposes will be pursued while work on large silicon-charge-coupled device (Si-CCD) format arrays will be completed. The technology demonstration model of a mechanical-magnetic bearing Stirling cooler will be initiated. Work will also continue on the experimental demonstration of the Joule-Thomson refrigerator with loads of up to 1 watt at temperatures around 20°K.

The computer science research program will continue expanding its efforts in software verification and validation technology for highly reliable systems and will evaluate techniques for managing complexity in large scale systems. Research in concurrent processing will be initiated, including work in system architectures for parallel processing, algorithm characterization techniques, an evaluation of programming languages which facilitate concurrency, and a characterization and evaluation of resource management techniques appropriate for operating systems of concurrent machines. The specification of a prototype heterogeneous data base management architecture will be completed which will enable NASA space data users to

access any data base independent of its physical distribution and specific organization. Circuit design principles and techniques will be developed for the verification of the fault tolerance and self-checking properties of fault-tolerant large-scale and very large-scale integrated (LSI and VLSI) devices. VLSI devices will be fabricated and experimentally evaluated to test theoretical approaches and predicted results.

In 1984, automation research will demonstrate the replacement of spacecraft controllers by expert systems. The design of an automated environmental control and life support system for space applications will be completed. Robotic vision will demonstrate the capability to track objects composed of curved surfaces moving through a visually cluttered scene. The robotic simulation system will include adaptive control of multiple link arms, multiple sensory modes including vision and force, and artificial intelligence capabilities for planning and executing robot activities.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Space energy conversion research and technology.....	18,081	19,800	17,400	18,000

OBJECTIVES AND STATUS:

The objectives of this research and technology program are: (1) to increase the performance, extend the operating environment, and decrease the cost of space electric power generation and energy storage subsystems; (2) to make the management and distribution of high levels of power in space cost-effective, autonomous and reliable; and (3) to enhance the performance of electric thrusters to provide a unique national capability in electric propulsion.

Power and electric thruster technologies are critical to, and will enable the large-scale utilization and exploration of space. In FY 1982, significant advances were made in a number of technology areas. A hydrogen-oxygen regenerative fuel cell technology demonstration breadboard has been assembled. An advanced, high capacity bipolar nickel-hydrogen battery concept has been successfully demonstrated. Both technologies enable high power space missions. Progress was made in understanding the chemistry of the lithium-thionyl chloride battery which is essential to its safe operation. In the photovoltaics program, a potentially low-cost, high-performance nine-unit miniature Cassegranian concentrator was fabricated. In support of this

activity, a miniature laboratory type gallium arsenide solar cell was demonstrated at an efficiency greater than 20 percent. A concept for increasing solar cell performance by changing incoming sunlight to a low-temperature radiation source was tested in initial laboratory configuration and an advanced concept for converting sunlight to electricity using the wave nature of light saw further theoretical development.

Development and testing of components of a power management and distribution breadboard facility continued. Improved components, switches, and circuit designs were also completed. A thermal canister for precisely controlling the temperature of space experiments was successfully demonstrated on the STS-4 Shuttle flight. Activities aimed at providing critical technology elements for a high power, sunlight independent, nuclear reactor power system continued. Potentially high-performance thermoelectric materials based on boron-carbon and lanthanum-sulfur alloys were synthesized and research continued to establish the promise of an alkali metal-based thermoelectric converter. Studies demonstrated the high potential of a thermal radiator based on a sheet of liquid drops to rid spacecraft of waste heat. In a major advance, two approaches for converting sunlight directly into a laser beam were demonstrated. The first approach converted light into heat which then stimulated the laser action, while the second used heated nitrogen atoms to transfer energy to CO₂ atoms which then produced the laser beam. The ion thruster program demonstrated substantial advancement in increasing the performance of inert gas thrusters. Designs and preliminary tests of high-performance pulsed plasma thrusters were also conducted.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

The \$2.4 million reduction resulted from the termination of research in laser propulsion, and from a reduction in the level of effort supporting ion thruster propulsion system technology and advanced energy conversion concepts. These funds have been redirected to support increased program activities in controls, human factors, and crew and life support within the space research and technology base.

BASIS OF FY 1984 ESTIMATE:

Major emphasis will be placed on evaluating and advancing the technology of both the regenerative hydrogen-oxygen fuel cell and bipolar nickel-hydrogen battery. Such systems are crucial to high capacity space power systems. Efforts will continue toward development of stable, high energy density lithium batteries. Photovoltaic activities will emphasize development of advanced gallium arsenide cells, novel low cost concentrator designs and concepts which may lead to substantially higher efficiencies. Power management and distribution activities will focus on developing improved components, advanced devices and subsystems for high power, high voltage applications such as on a future space station. Also included are rotary joints, high voltage transmission, automation and high voltage power system design guidelines for

space plasma environments. Nuclear reactor power system technology will be directed toward identifying and overcoming critical technology limits. Advanced thermoelectric converters will continue to be developed and the feasibility of alternative, high efficiency conversion technologies will be examined. The development of improved heat pipes and thermal radiators will continue along with research directed toward possible conversion and transmission of energy by solar-pumped lasers. In the area of electric propulsion, emphasis will be on increasing thrust per unit of weight, simplification of power processing equipment and further enhancement of thruster efficiency. Systems performance and erosion tests on the magnetoplasmadynamic thruster will also be completed.

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget <u>Estimate</u> (Thousands of	Current <u>Estimate</u> Dollars)	<u>1984</u> Budget <u>Estimate</u>
Multidisciplinary research.....	2,361	3,500	2,100	1,000

OBJECTIVES AND STATUS:

The objective of the multidisciplinary research program is to conduct long-range, basic research in the engineering and physical sciences focusing on high risk areas with revolutionary high potential payoff for space application and technology. A majority of the research is conducted at universities through the Physics And Chemistry Experiments in Space (PACE) program which supports studies for the design of basic science and engineering experiments that will resolve fundamental scientific questions and discover new phenomena in which conditions of zero or near zero gravity are prerequisite. Some of the studies include experiments on the vibrational modes of liquids, behavior of quantum fluids, combustion, and the dynamics of convection.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$1.4 million reduction in FY 1983 funding for the multidisciplinary research program area was implemented in order to facilitate a realignment of space research and technology base funding toward enhanced research efforts in controls, human factors, and crew and life support. Reduced areas of activities include theoretical mathematics and specific focused fundamental research efforts.

BASIS OF FY 1984 ESTIMATE:

The research supported under this activity will be maintained as a broad study of innovative ideas to exploit the unique opportunity of advancing basic knowledge in physics and chemistry through the use of the space environment. The university research conducted formerly under the Fund for Independent Research (FIR) will be conducted as an integral part of the disciplinary research and technology base programs.

	<u>1982</u> <u>Actual</u>	<u>1983</u> Budget Current <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		<u>1984</u> Budget <u>Estimate</u>
Controls and human factors research and technology.....	2,964	1,500	6,800	7,600

OBJECTIVES AND STATUS:

This program consists of two discipline areas, controls and human factors. The goal of the space controls research and technology program is to develop the design concepts and techniques required to enable precise pointing and stabilization of future spacecraft. Emphasis has been placed on developing distributed control concepts for active shape and vibration control, advanced modeling techniques for control system design, and adaptive systems to increase performance. Some recent accomplishments have included advanced theory development for control of distributed systems of complicated structures, and successful demonstration of distributed/adaptive control capability. The first integrated optical circuit chip for a fiber optics gyro has been developed and an advanced video based technique for rendezvous and docking of space systems is under development.

The goal of the human factors program is to develop techniques, data bases and standards for the design and evaluation of man/machine interfaces for use in space operations, including ground control. This program was initiated in FY 1983. Emphasis is on developing technology for man/machine function allocation strategies, teleoperations, extravehicular activity, crew station design and ground control man/machine interface design.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$5.3 million reflects the high priority being placed on critical new program activities in the controls and guidance and human factors areas in FY 1983. Specifically, this accelerates the major

thrust directed toward applying advanced controls and guidance technology and human factors principles to the improved design of future space vehicles, platforms, and other spacecraft.

BASIS OF FY 1984 ESTIMATE:

Specific FY 1984 control technology activities will include analytical research on new control concepts, computer simulation of applied control techniques, and experimental investigations to determine the actual performance that can be achieved through new control methods. Continued development of analytical techniques for onboard model error estimation will lead to adaptive controller designs. Advanced component demonstrations will begin on a version of an all-waveguide, integrated optics, fiber-optic gyro. An advanced three-dimensional shape and orientation sensing system which can be **used** to determine shape and vibration motion of large space structures will be carried to a preliminary design. Advanced space transportation systems guidance and control technology development initiated in FY 1983 will continue with emphasis on greater performance capabilities to reduce uncertainties and associated costs.

In FY 1984, the human factors program will continue developing technology for man/machine function allocation strategies, crew station design, teleoperations, extravehicular activity, and ground control man/machine interface design. A validated data base on the cognitive and behavioral capabilities and limitations of humans in space will be developed in order to provide the basis for an objective methodology for allocating functions to humans and to automation in highly autonomous spacecraft. Man-machine interface design technology will be developed which will enable advanced electronic display and control technology to be optimally used in crew stations, both in spacecraft and in ground control. This will include a technique to evaluate the protocols with which humans interface with crew stations, and a methodology for determining how highly flexible electronic displays should be formatted. Teleoperator design issues to be addressed include computer augmented visual displays and supervisory control systems. Human factors design criteria will be developed for head-up displays (HUD), restraint systems, and powered hand tools for use by astronauts in the extravehicular environment.

	<u>1982 Actual</u>	<u>1983</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1984</u> <u>Budget</u> <u>Estimate</u>
Space data and communications research and technology	16,902	17,900	18,100	19,300

OBJECTIVES AND STATUS:

The space data and communications program consists of two major areas: data systems and communication systems research and technology.

The overall objective of the data systems program is to provide technology needed to enable more effective transfer of useful data from sensor to user, extraction of information, and exchange of information to permit significant increases in space-derived information at reduced cost. Major sub-elements include data systems concepts, massively parallel processor (MPP), advanced digital synthetic aperture radar processor, onboard data processing, fiber optical data bus and components, ground optical disk data recorder, magnetic bubble flight experiment, and data base management technology. The MPP will be completed and delivered to the Goddard Space Flight Center in FY 1983. Testing of initial lots of custom integrated circuits for the MPP have been completed, verifying that this unique computer architecture will provide computational speed of up to 6 billion operations per second. A contract for development and delivery of a mass memory assembly with an on-line capacity of 10 trillion bits was awarded. This system will ingest data at rates up to 50 million bits per second and will automatically build catalogs of archived data packets and support on-line browsing by space data users. Delivery is scheduled for 1984.

The objective of the communications technology program is to provide high-performance, reliable, high-risk components and technology needed to insure continued United States preeminence in satellite communications and permit the distribution of processed data from future high rate shuttle payloads, planetary spacecraft, and low-earth orbit and geostationary-orbit platforms. In satellite communications technology, the traveling wave tube (TWT) development effort has produced a new ladder-like circuit called the "tunneladder" which is a potentially inexpensive alternative to conventional TWT's. TWT efficiency has been substantially improved through the use of multistage depressed collectors and materials having low secondary electron emission. In the 30/20 Gigahertz (GHz) solid state component area, efforts were initiated to develop a monolithic 20 GHz variable power amplifier and a 20 GHz monolithic phase control transmit module. Two phased-array-fed dual reflector antenna configuration studies were initiated in support of advanced array-fed antenna systems for the 1990's. The narrowband communications program completed conceptual designs of an ultrahigh frequency (UHF) feed array assembly as technology options for a future land mobile satellite service. Work has also proceeded to meet the data transfer/communications requirements of future NASA flight programs in the areas of spacecraft frequency sources, power amplifiers, modulators/excitors and low noise receivers.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$0.2 million increase reflects the NASA decision to increase the emphasis on communications technology within the space research and technology base in FY 1983.

BASIS OF FY 1984 ESTIMATE:

An optical mass data storage system will be developed which provides 10^{13} bits of on-line storage capacity. New thrusts in on-board fault-tolerant data systems technology for space station will be started, and definition of a high-speed general purpose flight computer program will begin.

In FY 1984, efforts will continue to: advance TWT technology, focus upon multistage depressed collectors constructed from low secondary yield material, and further the understanding of the tunneladder concept. Based upon configuration studies utilizing 30 GHz monolithic receive and 20 GHz monolithic transmit modules, proof-of-concept antenna systems will be designed and evaluated. Efforts to study the critical elements of laser intersatellite links will be initiated. Efforts to complete the feed system for a 15 meter reflector as a technology option for a future land mobile satellite service will be conducted. Activities in communications applicable to a space station such as laser ranging and tracking will be carried out.

	1982	1983		1984
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of	Dollars)	
Chemical propulsion				
research and technology	12,956	15,400	15,400	15,700

OBJECTIVES AND STATUS:

The objective of the chemical propulsion program is to develop technology to improve the life, performance, versatility, and reliability of chemical rocket propulsion systems for future space transportation and spacecraft systems. The program includes efforts directed at reusable propulsion for lower cost operations; high-performance, variable-thrust, and low-thrust propulsion for more mission-responsive vehicles; and efficient, long-life, auxiliary propulsion for precise attitude control and altitude maintenance functions.

Work on advanced, high pressure, oxygen-hydrogen propulsion systems was focused on providing the technology base for upgrading large, high-performance, reusable engines for more efficient Earth-to-orbit vehicles. Because early application of this technology will be utilized to extend the life of Space Shuttle Main Engine (SSME), selection of the initial task was sensitive to SSME technology needs. The design of a hybrid bearing suitable for SSME-class liquid hydrogen turbopumps was completed. The design was based on a similar small-scale version that has been successfully demonstrated in an upper-stage propulsion class turbopump. Testing of more conventional ball bearing designs was initiated using advanced test equipment capable of simulating transient and steady-state loads at high rotational speeds. Statistical life data as a function of loads, design characteristics, cooling and other measurable phenomena is being accumulated.

Technology for advanced upper stage propulsion received increased emphasis in FY 1983. Work on advanced, high-performance, variable-thrust, orbital transfer propulsion has produced several promising conceptual designs. Exploratory technology work to verify the feasibility of each design concept has been initiated. Advanced combustion chamber designs capable of transferring the high heat rates characteristic of these high-chamber pressure engines are being evaluated in hot-gas test rigs utilizing a facility which permits segments of the chamber to be tested in a rapid, low-cost manner. Design concepts for variable flow turbopumps capable of maintaining a high efficiency level over a wide range of flow rates and, thus, thrust levels have been selected.

Technology efforts directed specifically towards high-performance, long-life auxiliary propulsion systems for large spacecraft, such as platforms or space stations, are being initiated. A system analysis effort has been initiated to quantify the technology advances needed.

BASIS OF FY 1984 ESTIMATE:

The effort in advanced high-pressure, oxygen-hydrogen engines will continue to be directed toward developing a better understanding of component operating environments and, through analysis and experimentation, establishing the capability of designing for long life and repeated use. Improved modeling of bearing and seal design, rotor dynamics, structural dynamics, combustion, ignition, and fluid and gas dynamics will enhance future design capability for critical life-limiting components. Special emphasis will be given to developing analytical computer codes that can accurately simulate dynamic loads in hot-gas flow systems in order to predict and extend the life of these hot parts. Advanced nonintrusive sensor designs will be explored; these could provide a significant increase in engine diagnostic and automated inspection and checkout capability. A comprehensive effort in high-temperature materials development and evaluation, as well as advanced fabrication and manufacturing techniques, will support this technology area.

Research in reusable, high-performance oxygen-hydrocarbon propulsion will be continued. The focus will remain on fundamental work in the areas of combustion, stability, heat transfer and cooling. Experimental efforts will be directed toward areas which offer high potential for improved engine performance, reliability, and maintainability. The feasibility of using advanced composite materials for fabricating lightweight engine components will be explored.

Work on variable-thrust orbital transfer propulsion will increase, with emphasis on critical technologies including high-heat transfer combustor wall configurations, highly efficient turbine and pump designs, and advanced high-temperature combustor materials. In low-thrust propulsion, the efforts will continue toward characterizing small combustor performance, cooling and life, and demonstrating efficient hydrodynamic operation of very small pumps. This technology will provide a validated basis for the selection of propulsion system designs to satisfy a broad range of orbital transfer missions.

Auxiliary propulsion technology will be focused on component technology development for a gaseous oxygen-hydrogen system, including small thrusters, gas generators, heat exchangers, pumps and pump drive concepts, and flow control valves.

	1982 <u>Actual</u>	1983		1984
		<u>Budget Estimate</u> (Thousands of	<u>Current Estimate</u> Dollars)	<u>Budget Estimate</u>
Spacecraft systems research and technology	5 ,071	4,100	3 ,500	3,700

OBJECTIVES AND STATUS:

The objective of this program is to develop and demonstrate technology for the advanced Earth-orbiting and planetary spacecraft necessary to satisfy planned space missions. Research and technology activities are conducted in those areas where a systems approach is essential to bring individual discipline accomplishments into integrated technology capabilities. The goal is the effective transfer and use of technology in future spacecraft within acceptable levels of risk and cost.

The advanced Earth-orbiting spacecraft technology program includes Earth observation, scientific, and communications spacecraft. Efforts include defining the technology requirements, developing systems concepts, developing advanced analytical tools to aid in spacecraft design, and defining the flight experimental programs to validate broadly applicable technologies that will enable future planned missions.

The technology requirements for a hoop-column microwave radiometer have been defined. Flight experiments to validate antenna system technology are being designed to develop and verify the technology to satisfy these requirements. A first-order kinematics system synthesis and analysis capability, and an integrated RF/structures/controls performance prediction capability are being developed. Systems analysis effort is being conducted to define and assess the technology requirements and options for a 10-to 30-meter Large Deployable Infrared/Submillimeter Reflector (LDR) telescope; this is being followed by a more focused effort to refine selected mirror segment designs and assess their optical, control and structural requirements. A preliminary structures/controls interaction experiment concept has been defined and a detailed design and cost assessment has been initiated. The large solar array dynamics augmentation experiment has been tested and integrated into the Solar Array Flight Experiment (SAFE).

The planetary spacecraft activities are directed toward defining the system-level requirements for the use of aero-capture to increase the weight limits of orbiting spacecraft delivered to planets with atmospheres. Aero-capture is the technique of employing planetary atmospheric braking to remove energy from spacecraft or probes as opposed to the more conventional, but less efficient, technique of applying retro-propulsive thrust. A conceptual design of a Titan vehicle aero-capture spacecraft has been completed and system level requirements are being defined.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$0.6 million decrease in spacecraft systems research and technology is associated with the termination of space storable propulsion and Mariner Mark II technology tasks in FY 1983. These funds have primarily been redirected in support of high priority program activity in the controls, human factors, crew and life support technology within the space research and technology base.

BASIS OF FY 1984 ESTIMATE:

An effort will be initiated to identify the high leverage technologies for future commercial and military systems. , Included are the definition of applicable RF communications, optical communications and precision pointing, Earth observing, satellite payloads and spaceframe technologies.

The development of analytical tools will be expanded primarily for an integrated antenna analysis capability. This capability will allow more efficient analyses of proposed technology options and their

resulting impact on system and subsystems performance. The computer-aided design and analysis program capability will be expanded to include controls and integrated propulsion loading effects. The large deployable reflector systems study effort will be continued with a focus on a more detailed assessment of technology options. A major emphasis will be the development of systems simulation tools to enable the assessment of the sensitivity of individual subsystem improvements to overall system effectiveness. This is vital to the prioritization process for the selection of research and technology programs from the extensive candidates available.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Transportation systems research and technology	7,073	8,300	7,800	8,000

OBJECTIVES AND STATUS:

The objectives of this program are to: identify the technology requirements for advanced transportation vehicles to satisfy anticipated national needs and integrate these requirements into a comprehensive plan for a supporting technology base; develop technology programs which satisfy these requirements; and support the development, enhancement, and improvement of the space transportation system in areas of recognized technical expertise. These objectives are accomplished through system level studies, analyses, and requirements definition efforts, as well as system and discipline research and technology efforts utilizing ground-based facilities, in-space hardware, and instrumentation which permits the Shuttle orbiter to be used as an advanced research vehicle.

Flight data from both the Orbiter Development Flight Instrumentation (DFI) and the Orbiter Experiments (OEX) have been used to verify preflight predictions of the Shuttle's aerodynamic performance. Prediction methods have been refined and updated with flight data from DFI and OEX. These predictions have been used to certify the orbiter's thermal protection system, to support the expansion of the vehicle's operational envelope, and to support the completion of the STS operational flight test (OFT) program.

Instrumentation developed by the OEX program for determination of the aerodynamic coefficients of the orbiter was flown successfully on all Shuttle flights during FY 1982. Aerodynamic coefficient instrumentation has also been installed on the second orbiter, Challenger, and will support the

certification of Challenger beginning with STS-6. OEX instrumentation to measure tile-gap heating and thermal protection system surface catalytic heating properties was flown during FY 1982. Information from the tile gap experiment was also used to investigate anomalies experienced on early Shuttle flights associated with scorching of the gap filler material. Sensors which measure payload environment in the cargo bay were flown during 1982. Data collected is being used to validate structural and acoustic load models to predict payload bay environments. These models will provide design specifications and test environments for satellites and payloads flown in the future.

An effort to identify systems-level requirements for the use of aeroassist to recover reusable orbital transfer vehicles was initiated and programs addressing specific technology issues are being initiated to support a mid-1990's operational vehicle. The post-2000 Shuttle-replacement vehicle study identified new vehicle design approaches that could result in reduced cost and improved performance of future Earth-to-orbit transportation vehicles. Included in these results were the identification of technology for integral tankage concepts to reduce structural weight, vehicle structural and aerodynamics concepts compatible with a decoupled payload bay to increase operational flexibility, and ground and flight operations approaches which decrease vehicle turnaround time.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$0.5 million decrease in transportation systems research and technology base activities is primarily attributable to a reduced level of systems analysis activity in FY 1983. These funds have been redirected in support of high priority program activities in the controls and human factors discipline within the space research and technology base.

BASIS FOR FY 1984 ESTIMATE:

Systems analyses efforts will be conducted to define the scope and direction of technical programs needed to reduce the cost and improve the performance of future space transportation vehicles. The computerized conceptual design capability, which has been developed as an important tool for these studies, will be improved.' The study to identify systems level requirements for the use of aeroassist to recover orbital transfer vehicles will be expanded to provide a more detailed definition of vehicle system requirements, identify an optimal aero-braking maneuver, and assess the technology requirements for space-basing. The effort to investigate systems-level requirements of an orbit-on-demand launch vehicle will be completed: the objective is to identify the technology drivers and to develop the technology programs required to accommodate them.

In addition to the aerodynamic coefficient and thermal protection system packages previously described, other instrumentation packages developed under the OEX program will be flown on FY 1984 flights of Orbiter 102. These include low and high altitude research-quality air-data systems, a leeside temperature sensing system, and a more accurate vehicle coefficient determination package. These will be integrated into Orbiter 102 during vehicle modification periods.

An OEX program package to quantify the aerodynamic heating on the windward side of the orbiter during reentry (and thus the validity of the thermal protection system requirements) will be flown in conjunction with some FY 1984 flights. The instrumentation is mounted on the C-141 Kuiper Aircraft Laboratory and produces an infrared image of the orbiter at a selected reentry condition.

The Shuttle flights in FY 1984 will continue to be used as a source of flight data for the validation of analytical and ground facility test techniques. The resulting research-quality data base of critical vehicle characteristics will permit advanced vehicle concepts and designs to be analyzed with increased confidence, and, thus, designed with reduced technical risk and better cost control.

Two flight control experiments will be integrated into the orbiter in FY 1984. The first experiment will quantify orbiter handling qualities; the second will provide flight data on an advanced, adaptive autopilot. This data will permit the supporting technology programs to be responsive to actual flight conditions.

Several advanced thermal protection system test panels will be in development for flight opportunities in FY 1984/1985. These panels will provide actual flight data on more durable, higher performance concepts which could become options for retrofit on the current orbiter fleet, as well as candidates for subsequent orbiters. The panels will provide a validated data base for the thermal protection system for advanced post-Shuttle vehicles.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Platform systems research and technology	2,649	3,900	5,100	12,100

OBJECTIVES AND STATUS:

The objective of this program is to develop the systems-level research and technology capability which enables future manned and unmanned large space platforms. These research and technology activities require a multidisciplinary approach to meet mission objectives. The technology supports the system and subsystem developments necessary for future space platforms and space stations to satisfy science, technology, applications, and operational mission requirements. Efforts in the areas of systems analysis, operations technology, and subsystem technology are directed toward reducing the cost of station operations and increasing station versatility and performance.

Functional requirements definition of automated unmanned spacecraft are being completed and the techniques will be adapted for determining system-level functional requirements of an inhabited, highly automated space station. The requirements for automating a multi-hundred kilowatt power subsystem are being defined. Software development is being completed for simulation of a teleoperated satellite servicing system. Simulation of distributed control techniques applicable to large space platforms is being initiated. The initial studies of large structure subsystem interactions are being completed. A technology effort is being initiated for advanced life support systems capable of partial closure of the supply/waste cycle.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$1.2 million increase in platform systems research and technology funding in FY 1983 reflects the additional emphasis being placed on systems analysis, operations technology, and crew and life support technology. These capabilities are critical to any future program involving long duration human presence in space.

BASIS OF FY 1984 ESTIMATE:

For FY 1984, the platform systems research and technology program is grouped into three subprograms: systems analysis, operations technology, and subsystems technology.

The systems analysis effort will evaluate automated and autonomous system concepts, and analytical and experimental verification of space assembly and construction concepts. System-level functional requirements for space station autonomy will be used to determine information system architecture, human-machine partitioning, and automation technology requirements. A ground-based test program for deployable platform and space assembly concepts will be initiated; the results are expected to identify technology requirements which will enable man to efficiently participate in in-space construction, and the required level of automation to accommodate and compensate for his inabilities.

Operations technology includes experimental investigations of teleoperations and robotics through software simulation and hardware validation, and experimental efforts in stabilization and control operations. A hardware/software simulation of remote orbiting systems for the teleoperated servicing of satellites will be conducted. Stabilization and controls efforts will address advanced concepts involving distributed sensors and actuators to enable distributed dynamic control of a space station; the initial effort will be directed at the development of a high-fidelity ground simulation.

Subsystem technology activities will be modestly expanded in FY 1984 to prepare the technology base for a space station capable of cost effective operation and evolutionary growth in size and capability. Some elements of this expanded program are as follows: information systems research will be expanded to mature advanced data management concepts including adaptive information networks, high-speed data processing, high capacity storage, high-speed communications and transfer, and advanced expert systems for software design.

Human factors research will be conducted to produce advanced concepts, methodologies, and subsystems for habitability and optimal human productivity during long-term space operations. Technology development will include both air and water and environmental control and life support components and subsystems; space human factors and man-machine interaction; and the human interface to intelligent systems.

Advanced auxiliary propulsion technology will be developed to provide high-performance components for control of orbital attitude, drag make-up, and stationkeeping, as well as technology for acquisition, transfer, and long-term storage of requisite fuels.

Attitude control and stabilization technology will include advanced components and algorithms for distributed and adaptive control that accommodate significant changes in station configuration, because of modular growth or deployment, rendezvous, and docking operations. Particular emphasis will be placed on systems identification for in situ characterization of time-varying plant dynamics.

Energy management technology will focus on power generation, conversion, and storage, as well as thermal management which includes heat acquisition and transport. Advanced technology for an on-board energy utility system will be investigated as it pertains to high-voltage, high-power components, high-density storage, high-capacity thermal transport, and modular, expandable radiators.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	<u>1982</u>	<u>1983</u>		<u>1984</u>
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Space flight experiments.....	1,054	1,400	1,900	5,500
Long duration exposure facility.. ..	1,560	2,300	2,100	700
Ion auxiliary propulsion system.....	<u>740</u>	<u>700</u>	<u>900</u>	<u>1,000</u>
Total.....	<u>3,354</u>	<u>4,400</u>	<u>4,900</u>	<u>7,200</u>

OBJECTIVES AND STATUS:

The objective of the spacecraft systems technology program is to provide the capability to extend ground-based research and technology activities into the space environment using the Space Shuttle, Spacelab, and free-flying vehicles. The space environment uniquely provides the long-term, zero gravity and the actual combination of space vacuum and space radiation environments necessary to the development and characterization of many technologies important to future space systems. This program element encompasses the design, development, integration, and flight test of experiments, and the development of special purpose, reusable, flight research facilities for use in space. These in-space facilities are designed to reduce flight cost for that class of experiments requiring multiple flights.

Current activities include: the development and flight of the Long Duration Exposure Facility (LDEF), a Shuttle-delivered and retrieved 14-foot diameter free-flying experiment carrier; the Ion Auxiliary Propulsion System (IAPS) experiment package to be flown on an Air Force satellite; and, seven discipline technology experiments which are to fly as part of Spacelab or on Shuttle pallets.

The LDEF is currently in preparation for shipment to the Kennedy Space Center for experiment integration and final tests prior to the scheduled FY 1984 launch. The IAPS has been delivered to the contractor for integration with the DOD spacecraft. Integration activities will continue through FY 1983 and a portion of FY 1984. The discipline technology experiments are in various stages of readiness for flights in FY 1984 and FY 1985.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The \$0.5 million increase in spacecraft systems technology program funding reflects a redirection of funding from the research and technology base in order to place increased emphasis on high priority Spacelab payloads flight experiment activities in FY 1983. The space technology experiments flown to date on the Space Shuttle have demonstrated the high utility and cost-effectiveness of space-based research and experimentation.

BASIS OF FY 1984 ESTIMATE:

Technology experiments on missions scheduled for FY 1984 flights include the **IDEF**, the Solar Array Flight Experiment, the solar cell calibration facility, the tribology experiment, and a reflight of the Feature Identification and Location Experiment. Other experiments will be completing their integration and test programs in preparation for launch in FY 1985.

The IAPS will continue in the spacecraft integration and test activities directed towards a launch readiness in the latter portion of FY 1984.

The increased funding in FY 1984 for space flight experiments will permit completion of the design and the initiation of the development of several new in-space facilities and flight experiments. These include: concept definition and design activities for an in-space structures and controls experiment and a cryogenic fluid management in-space facility. Additional flight experiment and concept definition activities will be initiated based on evolving requirements identified in the research and technology base program, technology urgency and funding availability.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>STANDARDS AND PRACTICES</u>			
	<u>1982 Actual</u>	<u>1983</u>		<u>1984 Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u> (Thousands of Dollars)	
Standards and practices	3,000	3,000	3,000	4,600

OBJECTIVES AND STATUS:

The objective of the standards and practices program is to support Agency goals through activities in systems engineering; reliability and quality assurance; safety; software assurance; and program practices which reduce program risks, improve product confidence, and encourage good program procedures in the technical execution of NASA programs.

During FY 1982, the Office of the Chief Engineer was reorganized to consolidate agency-level safety, reliability and quality assurance activities, and to assume four new areas of responsibility (aerospace flight systems; data and communication systems engineering; test and environmental systems; and engineering technology). This expansion of the oversight function in the engineering discipline area has the objectives of improving product quality, increasing confidence in NASA's ability to achieve mission objectives and accelerating the pace of achieving greater productivity. In FY 1982 and in FY 1983, reliability and quality assurance activities have emphasized solving concerns related to degradation of critical electronic parts in space applications; laying a solid foundation for testing and qualifying very large scale integrated (VLSI) circuits for future use in the space program; assessing and mitigating the effects of space radiation on electronics in space; developing non-destructive test techniques for verifying product quality; evaluating NASA-wide software practices with goals to improve productivity and reduce costs; and continuing materials and parts, assurance activity. Program practices activities include continuing support to voluntary consensus efforts which will result in a new American Institute of Aeronautics and Astronautics (AIAA) standard for **symbols** and units for use in planning and design of large space structures; workmanship standards; support to the measurement of the Shuttle payload bay dynamic, acoustical and thermal environment; and providing electrostatic discharge information designed to achieve good practices which will minimize the potential loss of electronic systems containing microcircuit parts. In the area of safety, activities include assessing the ignitability of metals in oxygen; studies concerning safe siting of future

pressure vessels: development of an accident investigation training program: and a project to assess the use of an in-flight aircraft data recorder to enhance maintenance procedures.

BASIS OF FY 1984 ESTIMATE:

In support of the goals of the Agency, the FY 1984 standards and practices program will continue to conduct activities related to reliability and quality assurance, safety, software assurance, and program practices. The increase of funds from the FY 1983 level primarily reflects the increased responsibility of the restructured organization to address tasks directed toward systems engineering problems and toward technology areas affecting the efficiency and quality of NASA space and aeronautical products and testing. This increase in emphasis includes software engineering assurance, special technology reviews and risk assessments: improved assessment and evaluation of test facility capabilities, hardware and, particularly, software systems engineering assessments; and continuing special activities to maintain or improve productivity, quality and mission success. Non-destructive testing and evaluation techniques and standards will be extended to new materials, such as composites, and to developing pressure vessel hazard mitigation guidelines. The FY 1984 funds will also continue to provide for special Congressional or NASA directed taskings which result from technical problems arising from programmatic activities. Examples of recent special taskings are the examination of the FY 1983 aeronautical budget assumptions and a review of the Space Shuttle external tank production schedule, both tasks to be carried out by the continuing major NASA program change review capability provided by the National Academies of Sciences and Engineering. Other recent tasks include the aviation safety reviews at the Langley Research Center and the Johnson Space Center: evaluations of the Space Shuttle main engine test failures: an assessment of the solid rocket booster parachute failure on the fourth Shuttle flight; and an assessment of the extravehicular maneuvering unit (EMU) failures on the fifth Shuttle flight.

TRACKING AND
DATA ACQUISITION

i

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1982 <u>Actual</u>	1983 <u>Budget Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	1984 <u>Budget Estimate</u>	Page <u>Number</u>
Space network.....	21,800	112,800	103,800	294,700	RD 14-4
Ground network.....	237,457	243,500	242,400	231,500	RD 14-9
Communications and data systems.....	130,343	139,200	139,300	159,800	RD 14-20
Advanced systems.....	<u>12,500</u>	<u>13,400</u>	<u>13,400</u>	<u>14,200</u>	RD 14-29
Total.....	<u>402,100</u>	<u>508,900</u>	<u>498,900</u>	<u>700,200</u>	

Distribution of Program Amounts by Installation:

Marshall Space Flight Center.....	1,321	500	2,400	13,000
Goddard Space Flight Center.....	281,935	380,200	317,600	360,100
Jet Propulsion Laboratory	103,680	107,100	110,600	106,900
Ames Research Center.....	2,925	3,900	4,200	6,600
Headquarters	<u>12,239</u>	<u>17,200</u>	<u>64,100</u>	<u>213,600</u>
Total.....	<u>402,100</u>	<u>508,900</u>	<u>498,900</u>	<u>700,200</u>

OFFICE OF SPACE TRACKING AND DATA SYSTEMS
FY 1983 Congressional Budget Crosswalk
(Dollars in Millions)

Old Structure	TRA DAT	Net Ope	Spa Net	STD	TDR Rel	Mis Ope	Dee: Net	Ai	Ci	Di a	S: Li	Sj & a	Si	TI	Mi Fe	De					
	508.9	338.2	184.5	(120.7)	(46.0)	(17.8)	61.3	6.9	45.6	39.9	96.0	22.4	(6.0)	(5.5)	(10.9)	44.8		5.6	19.4	<u>13.4</u>	<u>61.3</u>
New Structure																					
T&DA	<u>508.9</u>																				
Space Network	<u>112.8</u>	<u>46.0</u>									<u>5.5</u>										<u>61.3</u>
TDRSS	61.3																				61.3
Space Network Opns. system Eng. & Supt.	33.5 18.0				33.5 12.5									5.5							
Ground Network	<u>243.5</u>	<u>188.9</u>									<u>54.6</u>										
STDN Systems	6.0												6.0								
STDN Operations	120.7			120.7																	
DSN Systems	44.8						61.3														
DSN Operations	61.3															44.8					
A&SR Support System	3.8																3.8				
A&SR Support Opns.	6.9							6.9													
Comm & Data Systems	<u>139.2</u>	<u>103.3</u>									<u>35.9</u>										
Communications Sys.	5.6																	5.6			
Communications Opns.	45.6								45.6												
Mission Facilities	10.9														10.9						
Mission Operations	17.8					17.8															
Data Processing Sys.	19.4																		19.4		
Data Processing Opns.	39.9									39.9											
Advanced Systems	<u>13.4</u>																				13.4

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1984 ESTIMATES

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND MTA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the Department of Defense and other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for sounding rockets, balloons, research aircraft, Earth orbital and planetary missions, and deep space probes. The program includes support of the Space Shuttle flight program. The various types of support provided include: tracking to determine the position and trajectory of vehicles in space: acquisition of scientific and space applications data from on-board experiments and sensors: acquisition of engineering data on the performance of spacecraft and launch vehicle systems: reception of television transmission from space vehicles: transmission of commands from ground stations to spacecraft: communication with astronauts: transfer of information between the various ground facilities and central control centers: and processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure safety of the crew. Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations. When the Tracking and Data Relay Satellite System (TDRSS) becomes operational, support will be provided by a system of tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. These interconnections provide the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to satisfy the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions: the Deep Space Network (DSN) which supports planetary and interplanetary flight missions; and the Tracking and Data

Relay Satellite System (TDRSS), which will provide all **low** Earth orbital mission support when **it** becomes fully operational. The STDN will remain the primary Earth orbital support network until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to insure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of selected STDN ground stations will be initiated. Certain facilities of the STDN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS, or to provide launch and Shuttle landing support. These remaining facilities, except for the launch and Shuttle landing support facilities, are to be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory (JPL). The consolidation, when completed, will provide a single network to support geosynchronous, highly elliptical, and planetary missions. The consolidated network will also support those older spacecraft in low Earth orbit which continue to provide useful data.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: the cost of TDRSS service; operations and maintenance of the tracking and data acquisition facilities; the engineering and procurement of equipment to sustain and modify the various systems to support continuing, new, and changing flight project requirements; and the investigation and development of advanced tracking and data acquisition systems and techniques.

CHANGES FROM FY 1983 BUDGET ESTIMATES:

The current estimate for FY 1983 is \$10.0 million below the budget estimate, reflecting application of a portion of the general Congressional reduction in the FY 1983 Appropriation request. The major portion of the \$10.0 million reduction occurred in the Space Network line and is due to a revision in the date for the initiation of TDRSS loan repayments and a decrease in the projected amount to be borrowed under the Federal Financing Bank loan. A second portion of the \$10.0 million reduction occurred in the Ground Network line item and resulted from decreased staffing and related support requirements in the STDN.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

	<u>SPACE NETWORK</u>				
	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of	Dollars)		
Tracking and data relay					
satellite system.....	---	61,300	51,300	242,900	RD 14-5
Space network operations	8,400	33,500	34,400	31,800	RD 14-6
Systems engineering and support..	<u>13,400</u>	<u>18,000</u>	<u>18,100</u>	<u>20,000</u>	RD 14-7
 Total.....	<u>21,800</u>	<u>112,800</u>	<u>103,800</u>	<u>294,700</u>	

OBJECTIVES AND STATUS:

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth-orbital spacecraft. The TDRSS itself consists of a three-satellite spacecraft system in geosynchronous orbit and a single ground terminal located at White Sands, New Mexico. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communication links interconnect the NASA elements of the network and any remotely located user facilities.

The FY 1984 request includes funding for: repayment of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; operations payments to the TDRSS contractor; manpower and services necessary to operate and maintain the NASA elements of the network; systems engineering, logistics, and documentation support services to the network elements; and testing for compatibility and interface verification with user spacecraft such as Space Telescope.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Tracking and data relay satellite system.	---	61,300	51,300	242,900

OBJECTIVES AND STATUS:

The Tracking and Data Relay Satellite System (TDRSS) objective is to provide space-to-space communication services between the TDRS and user spacecraft through a single ground terminal. From their position in geosynchronous orbit, the Tracking and Data Relay Satellites function as relays for all signals to and from the mission spacecraft. This unique system provides approximately a six-fold increase in orbital coverage over that provided by the complex of ground stations currently in use and is capable of accommodating data rates up to 300 megabits per second from a single user. These capabilities will provide tracking, command, telemetry, and communication services to the flight missions of the 1980's--the Space Shuttle era.

Intensive testing and integration activities are underway at the Kennedy Space Center (KSC) for the launch of the first TDRS, scheduled for early 1983, on STS-6. The second and third launches are scheduled for mid 1983 and the first half of 1984, to complete the initial operational constellation of TDRS. Environmental testing has been initiated on the second spacecraft and assembly of the third spacecraft is in process. The ground terminal is undergoing test and network integration to ensure readiness for the initial launch and early operations.

After a thorough review of NASA support requirements and their relationship to the operation of a shared service system, NASA recommended the restructure of the TDRSS contract to provide for a dedicated government system. This change to the service contract converts the TDRSS from a shared system providing support to both government space missions and commercial communication satellite services, to a system dedicated to providing support to space missions. Although the Space Communication Company (SCC) will remain as the owner-operator, it has relinquished its rights to the use of the commercial segment of the system. NASA will have the dedicated use of all six spacecraft provided through the service contract. The operational constellation of satellites will consist of three rather than four spacecraft, as the one formerly dedicated to commercial use will no longer be required. NASA gains improved management flexibility and control over the operation of the system and has the ability to make modifications to both spacecraft and ground systems to meet the needs of user missions. This contract change also provides the potential for extended system

life since there will be three, rather than two, replacement spacecraft available on the ground to restore full NASA service in the event of spacecraft failure or degradation.

CHANGES FROM 1983 BUDGET ESTIMATES:

The decrease of \$10.0 million reflects application of the general Congressional reduction in the budget request. Due to a revision in the date for initiation of loan repayments and a revised estimate in the total amount to be borrowed, loan payment requirements for FY 1983 were reduced.

BASIS OF FY 1984 ESTIMATE:

Under the terms of the TDRSS service contract, loans were extended by the Federal Financing Bank (FFB) to the Space Communication Company (SCC), the owner-operator of the TDRSS. Under the terms of the loan agreement and assignment, NASA will repay these loans directly to the FFB. In addition, NASA will make operations payments to SCC for services once NASA accepts TDRSS service. Acceptance occurs when two on-orbit spacecraft have been tested and are operating on station.

As discussed above, funding requested for FY 1984 is based in part on the restructuring of the TDRSS contract to provide for a dedicated government system.

	<u>1982</u> <u>Actual</u>	<u>1983</u>		<u>1984</u> <u>Budget</u> <u>Estimate</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	
Space network operations	8,400	33,500	34,400	31,800

OBJECTIVES AND STATUS:

The objective of Space Network Operations is to provide for the operation and maintenance of the associated NASA ground systems which, when combined with TDRS, provide a full array of reliable tracking, telemetry, command, and communication services to user spacecraft in low Earth orbit. Each of these systems provides specific functions for the Space Network.

The NASA Ground Terminal (NGT) monitors TDRSS performance and provides fault isolation monitoring for the network. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft, and the

Operations Support Computing Facility (OSCF) provides orbit determination, trajectory analysis, and position location for flight missions supported either via the Space Network or by the current Spaceflight Tracking and Data Network (STDN). The Bilateral Ranging Transponder System (BRTS) provides precision position location and orbit determination for the TDRS. The Simulation Operations Center (SOC) and the Compatibility Test Vans (CTV) provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission. These systems are undergoing test and integration to confirm readiness to support the launch of the first TDRS. TDRSS mission and user simulations are being conducted; tests of the individual systems are being accomplished and will culminate in a series of end-to-end tests of the entire network. The complex software of the NCC for the Initial Operational Capability (IOC) is undergoing test and verification. The White Sands BRTS is in the process of test and checkout with the ground terminal. Other BRT systems are ready for final calibration and delivery to remote site locations for installation.

Δ FROM FY 1983 ESTIMATE

The increase of \$.9 million is due to revised operational requirements for the Network Control Center.

BASIS OF FY 1984 ESTIMATES:

The funding request provides for contractor personnel to operate the network systems 24 hours per day, seven days per week, and to provide requisite hardware and software maintenance. A contract has been competitively awarded to provide these operation and maintenance functions. In addition, a variety of support services is provided in the areas of logistics, mission planning and documentation.

	1982	1983		1984
		Budget	Current	Budget
	<u>Actual</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Systems engineering and support.....	13,400	18,000	18,100	20,000

OBJECTIVE AND STATUS:

The objective of Systems Engineering and Support is to provide for the implementation and the required engineering services to design, implement, and sustain the NASA systems of the Space Network. Engineering services are supplied primarily through the operations contract and a number of small, highly specialized

engineering service contracts. Current emphasis is on the completion, test, and integration activities in preparation for the initial operations of the Space Network. Activities include test scenario design and development, system and subsystem level troubleshooting during simulations, end-to-end network testing, and operations procedure development.

CHANGES FROM FY 1983 ESTIMATES:

The increase of \$.1 million is due to a refinement in the estimate for Network Control Center hardware.

BASIS OF FY 1984 ESTIMATES:

Requested funding will provide for engineering support under the operations mission contract in the areas of systems engineering, performance and operations analyses, minor facility modifications, and network integration testing and interface verification. In addition, other contractors will supply sustaining engineering support, test equipment, and vendor maintenance for specialized equipment and subsystems within the Space Network. Design and analytical studies will be conducted on a wide array of items ranging from subsystem modifications to meet new mission requirements or to correct system deficiencies to the analysis of the radio frequency environment for potential impact on TDRSS and other network systems.

Funds are also requested for software and hardware development for the NCC Full Operational Capability (FOC), to complete procurement of replacement front-end processors for the NCC, and to complete the remaining implementation activities at the NASA Ground Terminal (NGT). The implementation of the FOC is required for upcoming missions such as the Space Telescope.

BASIS FOR FY 1984 FUNDING REQUIREMENTS:

	GROUND NETWORK				
	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of	Dollars)		
Spaceflight tracking and data network systems implementation..	3,900	6,000	6,000	8,100	RD 14-10
Spaceflight tracking and data network operations.....	120,536	120,700	118,200	102,500	RD 14-11
Deep space network systems implementation.....	36,900	44,800	45,300	38,100	RD 14-12
Deep space network operations.....	63,296	61,300	61,300	66,500	RD 14-15
Aeronautics and sounding rocket support systems implementation	6,255	3,800	3,800	8,100	RD 14-17
Aeronautics and sounding rocket support operations.....	<u>6,570</u>	<u>6,900</u>	<u>7,800</u>	<u>8,200</u>	RD 14-18
Total.....	<u>237,457</u>	<u>243,500</u>	<u>242,400</u>	<u>231,500</u>	

The Ground Network includes the Spaceflight Tracking and Data Network (STDN), consisting of 16 geographically dispersed ground stations (11 permanent and five special purpose stations), which support Earth orbital missions; the Deep Space Network (DSN), consisting of three stations approximately 120 degrees apart in longitude for continuous mission viewing, which supports planetary and interplanetary flight missions; and support for Aeronautics and Sounding Rocket (A&SR) programs at the Wallops Flight Facility (WFF), the Dryden Flight Research Facility (DFRF), and White Sands Missile Range, as well as instrumentation support at the National Balloon Facility at Palestine, Texas.

Funding for the ground network provides for operation and maintenance of the worldwide facilities, as well as engineering and procurement of equipment to sustain and modify network systems. The workload in FY 1984 includes ongoing support to Shuttle, Voyager, Dynamic Explorers, International

Ultraviolet Explorer, and the International Sun-Earth Explorer, as well as preparation for support of such upcoming missions as Galileo, the Voyager-Uranus encounter, and the Active Magnetospheric Particle Tracer Explorer (AMPTE). Support will be provided to aircraft programs such as the F-16 and F-111, the forward swept wing, and the use of drones for aerodynamic and structural testing.

The FY 1984 budget request reflects the planned phaseout of most of the STDN ground stations after TDRSS is operational. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL), or dedicated to support of launch and Shuttle landing operations. The consolidation will result in a single network to support geosynchronous, highly elliptical, and planetary missions.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Spaceflight tracking and data				
network systems implementation.....	3,900	6,000	6,000	8,100

OBJECTIVES AND STATUS:

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement and implementation of services to sustain network facilities and equipment to insure reliable tracking, command, and data acquisition support to ongoing scientific and applications satellite missions and the Space Shuttle, to selectively replace obsolete equipment for reliable launch support in the TDRSS era. Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 request includes funds for the replacement of obsolete and difficult-to-maintain equipment used for launch support at Bermuda and Merritt Island, Florida. The requirement for launch support from these sites will continue for the foreseeable future.

Equipment modifications are required in the network in FY 1984 to maintain the required level of proficiency to support a diverse and demanding workload and to assure the reliability of the major

systems. Accordingly, funds are required to replace portions of aging systems at the stations being retained, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in mission-to-mission support requirements.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Spaceflight tracking and data network operations.....	120,536	120,700	118,200	102,500

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network (STDN) system operations is to support all NASA Earth orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer (ISEE) missions. In addition, the network provides launch support to NASA automated planetary missions, and on a reimbursable basis, spaceflight missions of other nations, commercial firms, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of 16 geographically dispersed ground stations. These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew operations and safety, and other project related purposes.

There are 11 permanent STDN land stations located at: Fairbanks, Alaska; Goldstone, California; Greenbelt, Maryland; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; and Madrid, Spain. In addition to the 11 permanent stations, five additional facilities supplement the STDN, primarily for Space Shuttle support. A transportable station is located near NASA's Dryden Flight Research Facility (DFRF), California, for support of the Shuttle landings, and a small transportable station is located at New Smyrna Beach, Florida, for support of Shuttle launch and

landings. Also, three UHF/voice air-to-ground stations are located at Dakar, Senegal; Gaborone, Botswana, and Yarragadee, Australia, to provide additional voice coverage with the astronauts. Dakar has been augmented for S-Band operations. An Air Force station in the Indian Ocean is used to provide Shuttle support. An engineering test and network system training facility at GSFC is also maintained and operated as part of the STDN.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The decrease of \$2.5 million resulted from reductions taken in station staffing and network support.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding requirements provide for the maintenance and operation of the STDN until phasedown begins in the April/May time period. Included in the funding request are the related logistics support, network planning, scheduling, engineering, documentation and software programming costs associated with the operations of the network.

The initiation of TDRSS service permits closure of several STDN stations in FY 1984--Ascension, Guam, Hawaii, Santiago, Dakar, and Botswana and the termination of activities at the Air Force Indian Ocean station and Yarragadee, Australia. Cessation of operations will result in a reduction to FY 1984 funding requirements.

	<u>1982</u> <u>Actual</u>	<u>1983</u> <u>Budget</u> <u>Current</u> <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		<u>1984</u> <u>Budget</u> <u>Estimate</u>
Deep space network systems implementation	36,900	44,800	45,300	38,100

OBJECTIVES AND STATUS:

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The DSN is responsible for receiving science and engineering data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging in distance to over 3.7 billion kilometers from Earth. After the Tracking and Data Relay Satellite System (TDRSS) becomes operational, the DSN will also support spacecraft

much closer to Earth. This new set of spacecraft will include highly elliptical Earth orbiters and synchronous Earth orbital missions which will be in orbits higher than those supportable by the TDRSS.

The systems and facilities required to support spacecraft at the limits of the solar system are highly specialized and include the use of large aperture antennas electronically configured in a phased array for optimum reception of the extremely weak radio signals. The antennas use ultrasensitive, cryogenically cooled receivers and powerful transmitters. Extremely stable hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the DSN complexes and the Network Operations Control Center (NOCC).

The four major objectives for the DSN in the 1980's are as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive images at these great distances; (2) to consolidate the activities of the residual Spaceflight Tracking and Data Network (STDN) with the DSN after the TDRSS becomes fully operational in 1984; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits at altitudes that are beyond the support area of TDRSS); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the DSN, as it will be supporting many more spacecraft than in the past, and it will be working at extremely great distances (beyond the orbits of the known planets) by the end of the decade.

The next major planetary encounter will be of Uranus by Voyager 2 in 1986. This encounter will occur some 2.9 billion kilometers from Earth. At that time, Voyager 2 is expected to transmit the first images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of compound multiple antenna arraying (more than two antennas) during this Uranus encounter. In Australia, this will include the use of the 64-meter antenna of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support older near-Earth missions that are not compatible with the TDRSS. To support these older spacecraft in their extended mission phase, and to provide backup support to the TDRSS itself, existing 26-meter GSTDN antennas will be moved and colocated with the DSN facilities at Canberra and Madrid.

New deep space missions which will be supported by the network in the 1980's include the Jupiter orbiter and probe (Galileo) and the International Solar Polar Mission (ISPM). One or more of Halley's Comet rendezvous missions will also be supported for the international community on a reimbursable basis.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$.5 million in the FY 1983 budget estimate is due primarily to: advancement of the Galileo spacecraft Jupiter encounter and the decision to send the International Sun-Earth Explorer (ISEE) spacecraft to encounter the Giacobinni-Zinner Comet.

BASIS OF FY 1984 ESTIMATE:

Funding in the FY 1984 request provides for continuing the reconfiguration of the ground network facilities into a consolidated, modern, and highly reliable, automated network. The capabilities planned in the reconfiguration will provide for enhanced spacecraft-ground telecommunications and navigation precision while reducing overall maintenance and operations costs. Equipment required for this capability includes antenna monitors and controls, receiving and data handling systems, along with the necessary engineering and fabrication. Some equipment will be provided to augment the Parkes Antenna in Australia to properly handle and combine the signals received during the Voyager-Uranus encounter at that location.

In addition, funds are included for implementing a central signal processing center at each DSN complex. Instead of independent support facilities for each antenna, it will be possible to support all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized, shared maintenance and support facilities will also be provided.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager 2 at Uranus. As the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for extremely sensitive receiving equipment as well as increased antenna aperture through antenna arraying.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement in flight navigation accuracy.

concurrent with these important engineering changes, FY 1984 funds will be required to maintain the high level of reliability for support of time-critical spacecraft maneuvers as well as routine ongoing support.

This will be accomplished through a continuing program of equipment and facility refurbishment and modifications to assure compatibility of existing equipment with the new system being implemented in the network.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Deep space network operations.....	63,296	61,300	61,300	66,500

OBJECTIVES AND STATUS:

The three Deep Space Network (DSN) complex locations at Goldstone, California; Canberra, Australia; and Madrid, Spain, are approximately 120 degrees apart in longitude and permit continuous viewing of planetary spacecraft. Each complex currently consists of one 64-meter and one 34-meter diameter antenna; an additional 34-meter antenna is being constructed at Goldstone and Canberra.

A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field management responsibility for the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operations of the Network Control Center at JPL.

The current workload in the DSN consists of the two Voyager spacecraft, seven ongoing Pioneer spacecraft (Pioneer 6--11 and Pioneer Venus), the Viking 1 Mars Lander, and one Helios mission. Support of these missions will continue during FY 1984.

The Voyager 2 spacecraft is on a trajectory for an encounter with Uranus in early 1986, and should provide the first, detailed information on that distant planet. Voyager 1 is now about 2.4 billion kilometers from Earth on a trajectory that will take it out of the solar system. Of the older Pioneer spacecraft, Pioneer 10 is over 4.1 billion kilometers from Earth, and along with Pioneer 11 is proceeding on a path that will take them beyond the solar system. Pioneer 10 continues to be the most distant man-made object communicated with; each time data is received by the DSN, a new communications record is established. It now takes nearly seven hours for a radio signal traveling at the speed of light to make the round trip between Earth and Pioneer 10. The Pioneer 11 spacecraft, some 2.0 billion kilometers from Earth, continues to be

tracked. The Pioneer 6-9 spacecraft are provided support during solar conjunctions and during gravity wave experiments. The Helios 1 mission is continuing its orbit about the Sun.

The DSN facilities are also used on a noninterference basis for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar phenomena.

In addition to the activities associated with network modifications and the support cited above, the DSN operations workload includes preparation for several future missions including the ISEE-3 spacecraft as it makes the first comet intercept (Giacobinni-Zinner Comet), the Galileo spacecraft (the mission to Jupiter), Giotto (the reimbursable European Space Agency (ESA) mission to Halley's Comet), and the multi-national Active Magnetospheric Particle Tracer Explorer (AMPTE) mission. This support preparation requires thorough and complex testing, training, and engineering involving both hardware and software. These activities must be carried out simultaneously with the extensive ongoing DSN workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

In preparation for the Voyager 2 encounter with Uranus, an additional 34-meter antenna is being constructed at both Goldstone and Canberra. These antennas will be electronically combined with the other facilities at their respective complexes so as to further increase the receiver gain available at these two stations which are both key to capturing imaging data from Uranus. The DSN complex at Canberra, because of its southern hemisphere location, will have the best view of Voyager 2 at Uranus. At that location, an additional facility will be used at the time of encounter; that facility is the Australian 64-meter Radio Observatory at Parkes, which will be electronically combined with an array of DSN antennas. ESA is planning to use this same radio observatory facility in support of their Giotto mission to Halley's Comet. The arrival of Giotto at Halley's Comet at a time close to the Voyager 2 Uranus encounter will require close coordination between NASA, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and ESA in order to assure success.

BASIS OF FY 1984 ESTIMATE:

The DSN operations funding provides for the maintenance and operation of the network facilities, control center, and the support and engineering effort associated with continuing operation of the network. The funds requested for FY 1984 are based upon the ongoing workload, including the Voyager mission, Pioneer 6-11 missions, Pioneer-Venus extended mission, Helios mission, and Viking Lander mission, and the preparation required for the upcoming activities mentioned above.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Aeronautics and sounding rocket support systems implementation	6,255	3,800	3,800	8,100

OBJECTIVES AND SCOPE

The objective of the Aeronautics and Sounding Rocket Support (A&SR) Systems Implementation program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition, and range safety requirements of the aeronautical research conducted at the Wallops Flight Facility (WFF) in Virginia, the Dryden Flight Research Facility (DFRF) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops and other selected sites around the world.

BASIS OF FY 1984 ESTIMATE:

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which generally require about the same level of support from year to year. To support these programs, WFF provides fixed and mobile instrumentation systems; namely, radar, telemetry, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, and test and calibration equipment routinely replaced.

Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased replacement and refurbishment program is underway to insure reliable real-time data collection and handling support to meet current and future requirements.

Funds are also included in the budget request for implementation of a second telemetry acquisition system at the DFRF to permit support of two missions simultaneously in order to accommodate the increase in flight research activity of that facility, and a Telemetry Post-mission Processing System which will permit support of post-mission formatting and flight replays without interfering with real-time mission support.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of	Dollars)	
Aeronautics and sounding rocket support operations	6,570	6,900	7,800	8,200

OBJECTIVES AND STATUS:

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft and aeronautical programs conducted by the Wallops Flight Facility (WFF) and the aeronautical flight research programs of the Dryden Flight Research Facility (DFRF). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket program continues to be an active program with approximately 200 launches in FY 1982, the majority of which were conducted at WFF. In addition, there were over 50 large scientific balloon flights during the same period. At WFF, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and noise studies. Approximately 200 missions were conducted during 1982. In addition to support of sounding rocket, balloon, and aeronautical programs, instrumentation at WFF will continue to be utilized to support the Shuttle orbital flights.

Dryden Flight Research Facility operates the aeronautical test range which provides radar, telemetry and communications support for the performance of aircraft research and development programs. A variety of programs is conducted involving high performance aircraft, such as the F-111, F-14, F-16, F-104, F-8, and research vehicles such as the tilt-rotor research aircraft, and drones for aerodynamic and structural testing. Over 400 aeronautical research missions were supported at DFRF during FY 1982. DFRF was the prime landing site for STS-2, -3, and -4, and tracking and data acquisition support of Shuttle orbital flights will continue in the future.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$.9 million results from the decision to provide funding support for the sounding rocket and balloon launch activity at ranges off-site from WFF. These include the Poker Flats Research Range, the

Churchill Research Range, and an expedition to Peru to conduct atmospheric research with sounding rockets and balloon borne payloads. Further, NASA has assumed funding responsibility for the National Scientific Balloon Facility at Palestine, Texas, and rocket launch support at the White Sands Missile Range, New Mexico.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, communications, and data handling and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities. The effort funded represents a continuation of the baseline support provided to the aeronautics, sounding rocket, and balloon programs.

BASIS OF FY 1984 FUNDING REQUIREMENTS:COMMUNICATIONS AND DATA SYSTEMS

	1982	1983		1984	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>Number</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Communications systems implementation..	4,250	5,600	5,600	5,300	RD 14-21
Communications operations.....	39,781	45,600	45,600	59,700	RD 14-22
Mission facilities.....	8,900	10,900	10,900	11,500	RD 14-23
Mission operations.....	14,838	17,800	17,800	18,600	RD 14-24
Data processing systems implementation.	15,492	19,400	19,500	22,400	RD 14-25
Data processing operations.....	<u>47,082</u>	<u>39,900</u>	<u>39,900</u>	<u>42,300</u>	RD 14-27
Total.....	<u>130,343</u>	<u>139,200</u>	<u>139,300</u>	<u>159,800</u>	

OBJECTIVES AND STATUS:

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Communication circuits and services are necessary to transmit data between the remote tracking and data acquisition facilities, launch areas, and the Mission Control Centers. Real-time information and post-flight experiment analysis are crucial to determining the condition of the spacecraft and payloads for the generation of commands for spacecraft and payload control. Data received from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. Such support is mandatory for achieving mission objectives. Missions supported include Shuttle, NASA scientific and applications missions and international cooperative efforts.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Communications systems implementation	4,250	5,600	5,600	5,300

OBJECTIVES AND STATUS:

The objective of the Communications Systems Implementation program is to provide the necessary capability in NASA's Global Communications Network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in NASCOM are the procurement, implementation, and programming of a Control and Status System that can remotely control the configuration of the Tracking and Data Relay Satellite System (TDRSS) multiplexing system located at White Sands, New Mexico. Funding is also provided to replace equipment in the voice and data message switching system at the Goddard Space Flight Center (GSFC).

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and to complete the implementation and programming efforts on the Control and Status System which will remotely control the configuration of the baseline and high data rate multiplexing equipment located at the White Sands Ground Terminal, Johnson Space Center, and the Goddard Space Flight Center. Efforts will continue on the use of advanced digital techniques for Time-Division-Multiple-Access (TDMA) via satellite and on the use of fiber optic cables for high data rate distribution in support of Spacelab and Space Telescope.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Communications operations.....	39,781	45,600	45,600	59,700

OBJECTIVES AND STATUS:

NASA's Global Communications Network (NASCOM) interconnects, by means of leased voice, data, and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations.

The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real-time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditiously to users for analysis.

In order to meet high data transfer rate requirements, NASA has implemented and will continue to use digital and other newly developed techniques in providing communications support. The continuing availability of new technology provides for the transmission of increasing amounts of data in a cost effective and highly reliable manner.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 funding requirements for Communications Operations will provide the circuits and service required to operate and maintain the NASA Global Communications Network. International communications satellites and cables will continue to be used to provide digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

Funding increases in FY 1984 are due to the requirement for a 50 megabit per second (MBS) digital wideband service from the Tracking and Data Relay Satellite System facility at White Sands to both the Goddard Space

Flight Center and Johnson Space Center to support the high data rates of Spacelab and Landsat-4 Thematic Mapper, and for the upgrade of the White Sands baseline capability to 4 MBS to handle the lower data rates associated with Shuttle and its payloads.

A second increase in FY 1984 is due to a transfer in budget responsibility for the Program Support Communications Network which handles day-to-day voice, data, facsimile, and teleconference circuits among Headquarters, NASA Centers, and contractors. Funding is now centralized in the Office of Space Tracking and Data Systems for more efficient program management.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Mission facilities.....	8,900	10,900	10,900	11,500

OBJECTIVES AND STATUS:

The Mission Facilities Implementation program provides the systems capability for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control capability is realized through the provision of Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS) .

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the transmission of commands. Five POCC's monitor and currently control numerous spacecraft. In addition, a new dedicated control center is being implemented to control the operations of the Space Telescope to be launched in FY 1985. Related Mission Support Systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC interface facility and a closed circuit television and data communications system.

BASIS OF 'FY 1984 ESTIMATE:

The FY 1984 funding requirements will provide for the continuing development of the Space Telescope Operations Control Center. Two major activities, the Preliminary Operations Requirements and Test System (PORTS) and Payload Applications Software System (PASS), plus a test and validation effort will be underway to meet the FY 1985 launch date. The control center hardware installation will be completed and integration testing with the spacecraft on the ground will begin. The offline software which provides the high precision

telescope pointing, manipulation of the cameras and spectographs, pointing of the spacecraft antenna toward the TDRSS, and energy and momentum management of the vehicle itself, will require additional development and testing. Funds are necessary to assure that the PORTS, PASS, and Data Capture Facility operate as an integrated system.

In addition, FY 1984 funds will provide for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO) and Cosmic Background Explorer (COBE) spacecraft, and for sustaining activities such as changes to interface devices and replacement of obsolete equipment.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Mission operations	14,838	17,800	17,800	18,600

OBJECTIVES AND STATUS:

The Mission Operations program provides for the operation of five Payload Operations Control Centers (POCC's), a Mission Operations Center, and the related software and support services necessary for the monitoring and control of 18 in-orbit spacecraft.

The POCC's, which are the control facilities for spacecraft/payload operations, contain all of the necessary equipment, software, and personnel needed to monitor, evaluate, and control the performance of spacecraft and experiments. Each POCC is operated 24 hours per day, seven days per week by contractor personnel. For Shuttle launches with control center payloads, the POCC will issue commands and receive telemetry through the GSFC Shuttle Payload Interface Facility (SPIF). The SPIF will also process a variety of Shuttle-unique data and display these data to the POCC via closed circuit television.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 budget request includes funds to operate the POCC's and supporting facilities for the control of on-orbit missions. Also in FY 1984, POCC and Command Management software development activities will be initiated for both the COBE and GRO missions. Software to enable the POCC to work with the consolidated network will be developed and efforts will continue on SPIF software modifications.

Also included in the FY 1984 budget request are funds for software and related support services which include maintenance of a software library, coordination and display of launch data, computer generated command sequences, equipment maintenance, logistics, documentation, engineering services and operation of a closed circuit television/data communications system.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Data processing systems implementation	15,492	19,400	19,500	22,400

OBJECTIVES AND STATUS:

The Data Processing Systems Implementation program provides for the procurement of equipment and related services for the large computer complexes at the Goddard Space Flight Center which support both the operational and payload requirements of space missions. To meet operational requirements, these computer complexes determine spacecraft attitude and orbit, and generate commands to the spacecraft that provide the status of on-board subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters for analysis.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large complexes viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth orbiting spacecraft. The Image Processing Facility (IPF) is generating products for Landsat and Nimbus 7. The program to replace many of the old computers continues. The new Metric Data Facility was placed on line in mid-1982 and the old system retired. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

CHANGES FROM FY 1983 BUDGET ESTIMATE:

The increase of \$.1million is due to a minor adjustment of previous estimates.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 budget request will provide continued funding for phased replacement of the existing computer complex at the Goddard Space Flight Center (GSFC) which provides real-time support to NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control. This computer complex is approximately 17 years old. The system architecture of the existing system requires more extensive software development to meet new mission requirements. Replacement is needed because hardware and software maintenance is becoming more difficult and expensive, and more frequent outages are becoming a threat to spacecraft support.

The FY 1984 funding request provides for continuation of the phased computer replacement program for the flight dynamics, command management system, and the orbit computation system at GSFC. The orbit computation replacement system will have a complex task of not only supporting free-flyer spacecraft, but also the Shuttle and the Tracking and Data Relay Satellite System (TDRSS). Maintaining the TDRSS position accuracy will impose a significant demand on the orbit computation system resources.

In addition, funds are required for the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is necessary to handle the planned "Packet" telemetry requirement and to assure support over the long mission lifetime of the Space Telescope. The "Packet" telemetry concept allows the scientific data of an experiment to be handled with minimum involvement by the ground system, thus minimizing ground data processing time as well as insuring faster delivery of data to the experimenters. FY 1984 funds are requested also for a general purpose, multimission system to handle packet telemetry with the Gamma Ray Observatory (GRO) as its first user.

There is a continuing requirement to procure and maintain an adequate supply of spare parts to replace failure-prone and high-maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

	1982	1983		1984
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of	<u>Current</u> <u>Estimate</u> Dollars)	<u>Budget</u> <u>Estimate</u>
Data processing operations	47,082	39,900	39,900	42,300

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real-time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to separate the information obtained from various scientific experiments aboard the spacecraft, consolidate information for each experimenter, determine spacecraft attitude, and correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of the complex spacecraft. Examples of these activities are: the final checkout and acceptance of the operational orbit support software for the first Tracking and Data Relay Satellite (TDRS) to be launched early in 1983; and, the analysis and development of the operational software for the Bilateral Ranging Transponder System for the support of the TDRSS.

As part of the data processing activities, two facilities, the Image Processing Facility (IPF) and the Telemetry On-Line Processing System (TELOPS), have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF, initially established to handle image data from the Landsat-1, has continued to support the second and third Landsat spacecraft as well as Nimbus missions. These spacecraft are being supported with an all-digital system using high density and computer compatible tapes which have reduced the time required to provide data to users.

The Telemetry On-Line System (TELOPS) handles the non-image data. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Facility management, maintenance and operations, and software development support for the image and non-image data processing facilities are also provided. The operation of the Spacelab Data Processing Facility (SDPF) is included along with software development and maintenance required for attitude determination, flight maneuvers, and mission simulations. The SDPF will be completed during 1983 and prelaunch operations and training will begin.

BASIS OF FY 1984 ESTIMATE:

The FY 1984 budget request includes funds to operate the Image Processing Facility and the Telemetry On-Line Processing System to process data from currently orbiting satellites and from missions scheduled to be launched through FY 1984. The requirements for the acquisition and processing of data from the older satellites are under continual review as support for older missions is terminated or curtailed, as mission objectives are achieved, or when the experiment data is no longer useful or cost effective to acquire and process. Funds will also be required for operation of the SDPF.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Earth Radiation Budget Satellite, and the Gamma Ray observatory which will operate with the Tracking and Data Relay Satellite System. Complex software is required for spacecraft on-orbit and attitude control maneuvers and for the related data processing activities.

BASIS OF FY 1984 FUNDING REQUIREMENTS:

<u>ADVANCED SYSTEMS</u>				
	<u>1982 Actual</u>	<u>1983</u>		<u>1984 Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Advanced systems.....	12,500	13,400	13,400	14,200

OBJECTIVES AND STATUS:

The overall objective of the Advanced Systems program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions and near term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

This program remains a vital element in the space tracking and data acquisition program. Activity continues under this program to assess the dramatic changes taking place in the state-of-the-art in telecommunications and computer technology. Such effort is critical for proper planning and for the application of new technology to future support capabilities that are cost effective and reliable. Efforts include the investigation of upcoming missions and studies of ground systems and telecommunications links to determine design approaches and overall trade-offs for the lowest life-cycle costs to support future space missions.

BASIS OF FY 1984 ESTIMATE:

The Advanced Systems program is accomplished mainly through contracts managed by the Goddard Space Flight Center (GSFC) with emphasis on support of Earth-oriented satellite missions and by in-house personnel at the Jet Propulsion Laboratory (JPL) focusing on deep space missions.

The following are examples of activities planned for FY 1984. New and extremely precise radiometric tracking techniques will be investigated for determining angular direction of planetary missions to an accuracy of five nano-radians and establishing more accurate time standards sufficient for Earth-based navigation of future missions including flyby, orbiters, landers and probe releases. Such accuracy will

also be valuable to ground-based science experiments, including precision relativity and the search for gravity waves.

In the area of telecommunications, where improvements benefit all future spacecraft, investigations will continue on the application of technology for more effective use of ground facilities. Studies include the use of the 64-meter diameter antennas at millimeter wave frequencies and the development of a cryogenically cooled telemetry receiver and antenna feed system capable of multiple frequency operation at K, X, and S-bands. Technical support will continue on the evaluation of an X-band uplink transmitting system. The application of such technology allows for reductions in spacecraft weight and power, greatly improves telemetry reception at the distances of the planets Uranus and Neptune, increases the amount of imaging data that can be returned from distant spacecraft, and provides for new ground-based science experiments. The use of optical frequencies and satellite relay links to meet planetary telecommunication needs beyond the 1980's will be investigated in terms of cost and performance trade-offs over micro-wave options.

During the TDRSS era, Earth orbital missions will acquire and handle data rates up to 300 million bits per second, an increase over the current requirements by a factor of 20. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperture radars. New techniques and systems will be developed for ground transfer and processing of high volume data. These include computer assisted operations, digital processing of high volume data, better man-machine interfaces, and wide band satellite communications to distribute data to processing centers and users. Optical disc data storage and automated quality control of data will be investigated to facilitate handling the increased image data processing requirements anticipated for future missions.

Methods and techniques will be investigated to reduce future manpower needed to operate the mission control facilities and to provide the necessary real-time interaction between the spacecraft experimenters and their experiments. Studies include the use of automated mission control techniques such as voice control and use of microprocessors for distributed command management.

10-10-68 10:00 AM

10-10-68 10:00 AM
10-10-68 10:00 AM

10-10-68 10:00 AM

NASA HEADQUARTERS LIBRARY

Washington, DC 20546



3 1780 00002 8217

FISCAL YEAR 1984 BUDGET ESTIMATES